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A Checklist of the Wetland Indicator Species in Orange County, California

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The U.S. Fish and Wildlife Service "National List of Plant Species that Occur in Wetlands" for California (Reed, 1988a; 1988b) includes approximately 408 species from Orange County based upon Roberts (1989) and the synonymies in the Jepson Manual (Hickman, 1993; see Table 1). Among the wetland indicator flora, 273 species are native and 135 species are not native to Orange County. All 13 of the wetland indicator species in the Pteridophyta and their allies are native (Table 2). Among the dicots 176 species are native and 63 taxa are exotic. In the monocots there are 82 species are native and 46 taxa are non-native. Table 1 presents nearly a hundred synonyms or other other nomenclatural changes in the wetland indicator flora proposed by the authorities in the Jepson Manual (Hickman, 1993), and there are undoubtedly others. Bowler and Wolf (1994) present additional discussion of the wetland indicator flora (see also Bowler and Wolf, 1993). In a few cases such as *Acer negundo* the species is cited here as exotic because its presence in Orange County is likely not natural, though it is native to California. It should be noted that in a few cases, two old wetland indicator names with differing facultative status have been synonymized with a single Jepson Manual name. In these cases, the old name with its wetland indicator characteristics which matched describing authorities was retained and the other discarded. There is some confusion in attempting to rationalize this kind of nomenclatural linkage between Munz, Roberts, Reed, and Jepson. In most cases, however, this is not a problem, but it does demonstrate the need for a new, nomenclaturally accurate county, state, and national list.

It is not clear why some species were not included on the list, which is in need of nomenclatural and distributional updating as well a revision of taxa selected. Some of the designations, such as FACU as opposed to OBL, seem inaccurate, and need re-examination. This is particularly critical as federal definitions of wetlands change. Examples of the many species which an updated list might include are *Toxicodendron diversilobum* (Torrey & A. Gray) E. Greene, *Hemizonia parryi* E. Greene ssp. *australis* Keck, *Zostera pacifica* S. Watson, and the exotic *Vinca major* L., all of which appear to be at least facultative wetland species.

The wetland indicator *Navarretia prostrata* A. Gray was discovered in a previously unknown vernal pool sequence in Fairview Park, Costa Mesa by Bill Butler and Tony Bomkamp, and it is a first record for Orange County. Other new records not in Roberts (1989) contributed by Richard E. Riefner, Jr., are *Psilocarphus brevissimus* Nutt. and *Hainardia cylindrica* (Willd.) Greuter.

The indicator categories in Table 2 are as follows:

"Obligate Wetland (OBL). Occur almost always (estimated probability >99%) under natural conditions in wetlands.

Facultative Wetland (FACW). Usually occur in wetlands (estimated probability 67-99%), but occasionally found in nonwetlands.

Facultative (FAC). Equally likely to occur in wetlands or nonwetlands (estimated probability 34-66%).

Facultative Upland (FACU). Usually occur in nonwetlands (estimated probability 67-99%), but occasionally found in wetlands (estimated probability 1-33%).

Obligate Upland (UPL). Occur in wetlands in another region, but occur almost always (estimated probability 99%) under natural conditions in nonwetlands in the region specified" (Reed, 1988a; 1988b).

Based on Reed (1988a; 1988b), the Regional Indicator symbols in Table 2 are coded as follows:

1	Northeast	ME,NH,VT, MA CT, RI, WV, KY, NY, PA, NJ, MD, DE, VA, OH
2	Southeast	NC,SC,GA,FL, TN, AL, MS, LA, AR
3	North Central	MO, IA, MN, MI, WI, IL, IN
4	North Plains	ND, SD, MT (Eastern), WY (Eastern)
5	Central Plains	NE, KS, CO (Eastern)
6	South Plains	TX, OK
7	Southwest	AZ, NM
8	Intermountain	NV, UT, CO (Western)
9	Northwest	WA, OR, ID, MT (Western), WY (Western)
0	California	CA
A	Alaska	AK
C	Caribbean	PR (Puerto Rico), VI (US Virgin Isls.), CZ (Canal Zone), SQ (Swan Isls.)
H	Hawaii	HI (Hawaiian Isls.), AQ (American Samoa), GU (Guam), IQ (Misc. Pacific Isls.), MQ (Midway Isls.), TQ (Trust territories of the Pacific Isls.), WQ (Wake Isl.), YQ (Ryukyu Isls. Southern)

Table 1. A partial list of the taxonomic changes of wetland indicator taxa occurring in Orange County proposed by the authorities in the Jepson Manual (Hickman, 1993).

Previous Name	**Jepson Name**
Adiantaceae	Pteridaceae
Aizoaceae *pro parte*,	Molluginaceae
Aspidaceae	Dryopteridaceae
Najadaceae	Hydrocharitaceae
Salvinaceae	Azollaceae
Saxifragaceae *pro parte*	Grossulariaceae
Ophioglossaceae	
Ophioglossum lusitanicum var. *californicum*	*Ophioglossum californicum*
Aizoaceae	
Mollugo verticillata	Moved to Molluginaceae

Anacardiaceae

Rhus trilobata var. *anisophylla*, var. *quinata*, ?var. *pilosissima* (presumed synonym)	*Rhus trilobata*

Apiaceae

Caucalis microcarpa	*Yabea microcarpa*

Apocynaceae

Apocynun cannabinun var. *glaberrimum*	*Apocynum cannabinun*

Asteraceae

Achillea millefolium var. *californica*	*Achillea millefolium*
Ambrosia psilostachya var. *californica*	*Ambrosia psilostachya*
Aster hesperius	*Aster lanceolatus* ssp. *hesperius*
Baccharis glutinosa	*Baccharis salicifolia*
Gnaphalium chilense var. *chilense*	*Gnaphalium stramineum*
Grindelia robusta	*Grindelia camporum* var. *bracteosa*
Happlopappus venetus	*Isocoma menziesii*
Helianthus annuus var. *lenticularis*	*Helianthus annuus*
Hemizonia pungens	Exotic (Roberts, 1989); not cited in Hickman (1993); Wetland Indicator but presumed synonym; excluded here.
Matricaria matricarioides	*Chamomilla suavolens*
Lasthenia glabrata var. *coulteri*	*Lasthenia glabrata*
Solidago canadensis var. *scabra*; not cited but presumed included in synonymy	*Solidago canadensis* ssp. *elongata*
Xanthium strumarium var. *canadense*	*Xanthium strumarium*

Boraginaceae

Heliotropium curassavicum var. *oculatum*	*Heliotropium curassavicum*

Brassicaceae

Barbarea orthoceras var. *dolichacarpa*	*Barbarea orthoceras*
Nasturtium officinale	*Rorippa nasturtium-aquaticum*
Rorippa curvisiliqua var. *occidentalis*	*Rorippa curvisiliqua*

Campanulaceae

Triodanis perfoliata var. *biflora*	*Triodanis biflora*

Callitrichaceae

Callitriche longipedunculata	*Callitriche marginata*

Caprifoliaceae

Sambucus caerulea	*Sambucus mexicana*

Caryophyllaceae

Cerastium fontanum ssp. *trivale*	*Cerastium fontanum* ssp. *vulgare*

Chenopodiaceae

Arthrocnemum subterminale	*Salicornia subterminalis*
Atriplex argentea var. *expansa*	*Atriplex argentea* var. *mohavensis*
Atriplex lentiformis var. *breweri*	*Atriplex lentiformis* ssp. *lentiformis*
Atriplex patula ssp. *hastata*	*Atriplex triangularis*
Sueda taxifolia var. *pubescens*	*Sueda taxifolia*

Convolvulaceae

Cressa truxillensis var. *vallicola*	*Cressa truxillensis*
Dichondra repens Taxonomic status not clear	Name is a Wetland Indicator; presumed synonym, excluded here.

Crassulaceae

Crassula saginoides	*Crassula aquatica*
Crassula connata var. *erectoides*	*Crassula connata* (presumed synonym)

Fabaceae

Amorpha fruticosa var. *occidentalis*	*Amorpha fruticosa*
Glycyrrhiza lepidota var. *glutinosa*	*Glycyrrhiza lepidota*
Psoralea macrostachya	*Hoita macrostachya*

Psoralea orbicularis	*Hoita orbicularis*
Lamiaceae	
Stachys rigida	*Stachys ajugoides* var. *rigida*
Malvaceae	
Sidalcea neomexicana var. *thurberi*	*Sidalcea neomexicana*
Najadaceae	
Najas guadalupensis	Transferred to Hydrocharitaceae
Oleaceae	
Fraxinus velutina var. *coriacea*	*Fraxinus velutina*
Onagraceae	
Boisduvalia densiflora	*Epilobium densiflorum*
Plantaginaceae	
Plantago bigelovii ssp. or var. *californica*	*Plantago elongata*
Plantago insularis	*Plantago ovata*
Plantago hirtella ssp. *galeottiana*	*Plantago subnuda*
Plantago rhodosperma	*Plantago virginica*
Polemoniaceae	
Microsteris gracilis var. *gracilis*	*Phlox gracilis*
Polygonaceae	
Persicaria amphibia var. *amersa*	*Polygonum amphibium* var. *emersum*
Persicaria hydropiperoides var. *asperifolium*	*Polygonum hydropiperoides*
Persicaria lapathifolia	*Polygonum lapathifolium*
Persicaria punctata	*Polygonum punctatum*
Persicaria vulgaris	*Polygonum persicaria*
Polygonum aviculare	*Polygonum arenastrum*
Rumex maritimus var. *fueginus*, var. *persicariodes*, *Rumex fueginus*, *Rumex persicariodes*	*Rumex maritimus*
Portulaceae	
Calandrinia ciliata var. *menziesii*	*Calandrinia ciliata*

Salicaceae	
Populus fremontii var. *fremontii*	*Populus fremontii* ssp. *fremontii*
Salix lasiandra var. *lancifolia*	*Salix lucida* ssp. *lasiandra*
Scrophulariaceae	
Castilleja stenantha	*Castilleja minor* ssp. *spiralis*
Mimulus nasutus	*Mimulus guttatus*
Solanaceae	
Nicotiana bigelovii var. *wallacei*	*Nicotiana quadrivalvis*
Physalis ixocarpa	*Physalis philadelphica*
Urticaceae	
Parietaria floridana	*Parietaria hespera*
Verbenaceae	
Verbena robusta	*Verbena lasiostachys* var. *scabrida*
Cyperaceae	
Cyperus alterifolious	*Cyperus involucratus*
Cyperus aristatus	*Cyperus squarrosus*
Cyperus niger var. *capitatus*	*Cyperus niger*
Cyperus niger var. *castaneus*	*Cyperus bipartitus*
Eleocharis palustris	*Eleocharis macrostachya*
Scirpus acutus	*Scirpus acutus* var. *occidentalis*
Scirpus cernuus var. *californicus*	*Scripus cernuus*
Juncaceae	
Juncus acutus var. *sphaerocarpus*	*Juncus acutus* ssp. *leopoldii*
Orchidaceae	
Habenaria unalascensis	*Piperia unalascensis*
Poaceae	
Agropyron trachycaulum	*Elymus trachycaulus* ssp. *trachycaulus*
Agrostis semiverticillatas	*Agrostis viridis*
Agrostis exarata var. *minor* (presumed synonym)	*Agrostis exarata*
Agrostis stolonifera var. *palustris*	*Agrostis stolonifera*

Andropogon glomeratus	*Andropogon glomeratus* var. *scabriglumis*
Bromus hordeaceus ssp. *hordeaceus*	*Bromus hordeaceus*
Bromus rubens	*Bromus madritensis* ssp. *rubens*
Crypsis niliaca	*Crypsis vaginiflora*
Distichlis spicata var. *stricta*	*Distichlis spicata*
Elymus condensatus	*Leymus condensatus*
Elymus triticoides	*Leymus triticoides*
Eragrostis pilosa	*Eragrostis pilosa* var. *pilosa*
Hordeum californicum	*Hordeum brachyantherum*
Monerma cylindrica	*Hainardia cylindrica*
Pancium capillare var. *occidentale*	*Pancium capillare*
Poa fendleriana	*Poa fendleriana* var. *longiligula*
Poa pratensis	*Poa pratensis* var. *pratensis*
Setaria geniculata	*Setaria gracilis*

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Table 2 (following pages). Orange County wetland indicator taxa, their habit, distribution and status as indicator species throughout their distributions, based on Reed (1988a; 1988b). Note that the nomenclature and authority listings follow Hickman (1993), rather than Roberts (1989) or Reed. The key to the abbreviations of plant habit (Reed, 1988b) is as follows: A= annual; B= biennial; E= emergent; F= forb; F3 = fern; G= grass; GL = grasslike; H= partly woody; HS = half shrub; H2 = horsetail; + = parasitic; P= perennial; P3 = pepperwort; S= shrub; $= succulent; T= tree; Z= submerged; /= floating; - = saprophytic; V = herbaceous vine; W = waterfern; WV = woody vine.

NATIONAL LIST OF PLANT SPECIES THAT OCCUR IN WETLANDS: 1988—SUMMARY OF REGIONAL INDICATORS

SCI-NAME	NAT-IND	R0-IND	REGION	HABIT
PTERIDOPHYTES				
Azollaceae—Mosquito Fern Family (1 native; no exotics)				
Azolla filiculoides Lam.	OBL	OBL	1,2,7,8,9,0,H	P/W
Blechnaceae—Deer Fern Family (1 native; no exotics)				
Woodwardia fimbriata Sm.	FACW,FACW+	FACW+	7,8,9,0	PF3
Dennstaedtiaceae—Bracken Family (1 native; no exotics)				
Pteridium aquilinum (L.) Kuhn var. *pubescens* L. Underw.	FACU,FAC-	FACU	1,2,3,4,5,6,7,8,9,0,A,C,H	PF3
Dryopteridaceae—Wood Fern Family (1 native; no exotics)				
Cystopteris fragilis (D.) Bernh.	FACU,FACU+	FACU	1,2,3,4,5,6,7,8,9,0,A.	PF3

Equisetaceae—Horsetail Family (4 natives; no exotics)				
Equisetum arvense L.	FACU,FACW-	FAC	1,2,3,4,5,6,7,8,9,0,A	PH2
Equisetum hyemale L. ssp. *affine* (Engelm.) Calder & R.H. Taylor	FAC+,FACW	FACW	1,2,3,4,6,7,8,9,0,A	PH2
Equisetum laevigatum A. Braun	FAC,FACW	FACW	1,2,3,4,5,6,7,8,9,0	PH2
Equisetum telmateia Ehrh. ssp. *braunii* (Milde) R.L. Hauke	FACW,OBL	OBL	1,3,9,0	PH2
Marsileaceae—Marsilea Family (2 natives; no exotics)				
Marsilea vestita Hook .& Grev.	OBL	OBL	2,3,4,5,6,7,8,9,0	PEP3
Pilularia americana A. Braun	OBL	OBL	2,3,5,6,9,0	PEP3
Ophioglossaceae—Adder's Tongue Family (2 natives; no exotics)				
Ophioglossum californicum Prantl	FACW	FACW	0	PF3
Pteridaceae—Brake Family (1 native; no exotics)				
Adiantum capillus-veneris L.	FACU,FACW+	FACW	1,2,3,4,6,7,8,0,C,H	PF3

ANGIOSPERMS—Flowering Plants

DICOTYLEDONES (Magnoliopsida)—Dicots

Aceraceae—Maple Family
(1 native; 1 exotic)

Acer macrophyllum Pursh.	FACU,FAC	FAC	9,0	T
**Acer negundo* L.	FAC,FACW	FACW	1,2,3,4,5,6,7,8,9,0	T
**var. californicum* (Torrey & A. Gray) Sarg.				

Aizoaceae—Fig-Marigold Family
(1 native; 1 exotic)

**Mesembryanthemum nodiflorum* L.	FACU	FACU	0	AF
Sesuvium verrucosum Raf.	FACW-,FACW+	FACW	5,6,7,8,9,0	AP$F

Amaranthaceae—Amaranth Family
(2 natives; 2 exotics)

**Amaranthus albus* L.	FACU-,FACU	FACU	1,2,3,4,5,6,7,8,9,0	AF
Amaranthus blitoides S. Watson	FACU,FACW	FACW	1,2,3,4,5,6,7,8,9,0,A	AF
Amaranthus palmeri S. Watson	FACU-,FACU	FACU	1,2,3,5,6,7,8,0	AF
**Amaranthus retroflexus* L.	FACU-,FAC-	FACU	1,2,3,4,5,6,7,8,9,0,A	AF

Anacardiaceae — Sumac Family
(1 native 1 exotic)

Rhus trilobata Torrey & A. Gray	FAC?	NI	3,4,5,6,7,8,9,0	S
**Schinus terebenthifolius* Raddi	FAC	NO	2,C,H,O	T

Apiaceae (Umbelliferae)—Carrot Family
(8 natives; 3 exotics)

**Apium graveolens* L.	FAC-,FACW	FACW*	1,2,3,6,7,8,9,0	PF
Berula erecta (Hudson) Cov.	OBL	OBL	1,2,3,4,5,6,7,8,9,0	PF
Bowlesia incana Ruiz Lopez & Pavon	UPL,FAC+	FACU*	2,6,7,0	AF
Cicuta douglasii (DC.) J. Coulter & Rose	OBL	OBL	3,7,8,9,0,A	PF
**Conium maculatum* L.	FAC,OBL	FACW	1,2,3,4,5,6,7,8,9,0	BF
**Foeniculum vulgare* Miller	UPL,FAC	FACU	1,2,3,5,6,7,8,9,0,C,H	BPF
Hydrocotyle umbellata L.	OBL	OBL	1,2,3,6,7,9,0,C	P/F
Hydrocotyle verticillata Thurb.	OBL	OBL	1,2,3,6,7,8,9,0,C,H	PF
Oenanthe sarmentosa J.S. Presl	OBL	OBL	9,0,A	PZF
Perideridia gairdneri (Hook. & Arn.) Mathias	FACU,FACW	FACW	4,7,8,9,0	PF
Yabea microcarpa Hook. & Arn.	UPL,FACU+	UPL	7,8,9,0	AF

Apocynaceae—Dogbane Family
(1 native; no exotics)

Apocynum cannabinum L.	FACU,FAC+	FAC	1,2,3,4,5,6,7,8,9,0	PF

Araliaceae—Ginseng Family
(1 native; no exotics)

Aralia californica S. Watson	FAC+.FACW	FACW	9,0	PF

Asclepiadaceae—Milkweed Family
(2 natives; no exotics)

Asclepias fascicularis Decne.	FAC-,FAC	FAC	7,8,9,0	PF

Sarcostemma cynanchoides Decne. ssp. *hartwegii* (Vail) R. Holm.	FACU,FAC	FAC	2,6,7,8,0	PVH

Asteraceae (Compositae)—Sunflower Family
(36 natives; 24 exotics)

**Achillea millefolium* L.	FACU	FACU	1,2,3,4,5,6,7,8,9,0,A,H	PF
Achyrachaena mollis Schauer	FAC	FAC*	0	AF
Ambylopappus pusillus Hook. & Arn.	FACW-	FACW-	0	AF
Ambrosia psilostachya DC.	FACU-,FAC	FAC	1,2,3,4,5,6,7,8,9,0	PF
**Ambrosia trifida* L.	FAC,FACW	FAC	1,2,3,4,5,6,7,8,9,0	AF
**Anthemis cotula* L.	UPL,FACU+	FACU	1,2,3,4,5,6,7,8,9,0,A,H	AF
**Artemisia biennis* Willd.	FACU-,FACW	FAC	1,2,3,4,5,7,8,9,0,A	ABF
Artemisia douglasiana Besser	FAC,FACW	FACW	8,9,0	PF
Aster bernardinus H.M. Hall	OBL	OBL	0	PF
Aster chilensis Nees	FACU,FACW-	FAC	4,7,8,9,0	PF
Aster lanceolatus Willd. ssp. *hesperius* (A. Gray) Semple & J. Chmielewski	OBL	OBL	3,4,5,6,7,8,9,0	PF
Aster subulatus Michx. var. *ligulatus* Shinn.	FACW,OBL	FACW	1,2,3,5,6,7,8,0,C,H	AF
Baccharis douglasii DC.	OBL	OBL	9,0	HS
Baccharis emoryi A. Gray	FACW	FACW	7,8,0	S
Baccharis salicifolia (Ruiz Lopez & Pavon) Pers.	FACW-,FACU	FACW-	6,7,8,0	S
Baccharis sarathroides A. Gray	FAC-,FAC	FAC	7,8,0	S
Baccharis sergiloides A. Gray	FACU,FAC	FAC	7,8,0	S
**Bidens cernua* L.	FACW+,OBL	OBL	1,2,3,4,5,6,7,8,9,0,A	AF
Bidens laevis (L.) Britton, Sterns & Pogg.	OBL	OBL	1,2,3,6,7,8,0,H	APF

**Bidens pilosa* L.	FACW-,FACW	FACW	1,2,6,7,0,C,H	AF
Brickellia californica (Torrey & A. Gray) A. Gray	UPL,FAC	FACU	5,6,7,8,9,0	S
Chamomilla suaveolens(Pursh) Rydb.	UPL,FACU	FACU	1,2,3,4,5,6,7,8,9,0,A	AF
**Cirsium arvense* (L.) Scop.	FACU-,FAC	FAC-	1,2,3,4,5,7,8,9,0,A,H	PF
**Cirsium vulgare* (Savi) Ten.	UPL,FAC	FACU	1,2,3,4,5,6,7,8,9,0,A,H	BF
Conyza coulteri A. Gray	FAC,FACW-	FAC+	2,6,7,8,0	AF
**Cosmos bipinnatus* Cav.	FACU-,FACW	NI	1,2,3,7,8,0	AF
**Cotula coronopifolia* L.	FACW+,OBL	FACW+	7,8,9,0,A	PF
Erigeron philadelphicus L.	FACU,OBL	FAC	1,2,3,4,5,6,7,8,9,0	BF
Euthamia occidentalis Nutt.	FACW,OBL	OBL	3,4,5,7,8,9,0	PF
**Gnaphalium luteo-album* L.	FAC,FACW	FACW-	2,7,8,9,0	AF
Gnaphalium palustre Nutt.	FAC+,OBL	FACW	4,5,7,8,9,0	AF
Gnaphalium stramineum Kunth	FAC-,FAC+	FAC-	1,2,4,6,7,8,9,0	ABF
Grindelia camporum E. Greene var. *bracteosum* (J. Howell) M.A. Lane	FACU	FACU	0	PF
Helenium puberulum DC.	FACW	FACW	9,0	APF
Helianthus annuus L.	FACU,FAC	FAC-	1,2,3,4,5,6,7,8,9,0,A,C	AF
**Helianthus ciliaris* DC.	FAC	NI*	3,5,6,7,8,9,0	PF
Helianthus nuttallii Torrey & A. Gray ssp. *parishii* (A. Gray) Heiser	FAC,FACW	FACW	3,4,5,6,7,8,9,0	PF
Hemizonia paniculata A. Gray	FACU	FACU*	0	AF
**Hypochoeris radicata* L.	FACU?	NO	H	PF
Isocoma menziesii (Hook. & Arn.) G. Nesom	FACW	FACW*	0	S
Iva axillaris Pursh ssp. *robustior* (Hook.) Bassett	FACU,FACW	FAC	4,5,6,7,8,9,0	PEFH
Jaumea carnosa (Less.) A. Gray	OBL	OBL	9,0	PF

**Lactuca serriola* L.	FACU,FAC	FAC	1,2,3,4,5,6,7,8,9,0,H	ABF
Lasthenia californica Lindley	UPL,FACU	FACU*	7,9,0	APF
Lasthenia glabrata Lindley	FACW	FACW	9,0	AF
**Picris echioides* L.	UPL,FAC	FAC*	1,3,4,0	AF
Pluchea odorata (L.) Cass.	FACW	NO	2,C,H	AEF
Pluchea sericea (Nutt.) Cov.	FACW-,FACW	FACW	6,7,8,0	S
Psilocarphus brevissimus Nutt.	FACW+,OBL	OBL	0+?	AF
Psilocarphus tenellus Nutt. var. *tenellus*	FAC,FACW	FAC	9,0	AF
**Senecio vulgaris* L.	UPL,FAC	NI*	1,2,3,4,5,6,7,8,9,0,A,H	AF
**Solidago canadensis* L. ssp. *elongata* (Nutt.) Keck	FACU,FACU+	FACU	1,2,3,4,5,6,7,8,9,0,A	PF
Solidago confinis Nutt.	FAC	FAC	8,0	PF
**Sonchus arvensis* L.	UPL,FAC	FACU	1,2,3,4,5,6,7,8,9,0,A	PF
**Sonchus asper* (L.) Hill	FACU,FACW	FAC	1,2,3,4,5,6,7,8,9,0,A,C,H	AF
**Sonchus oleraceus* L.	UPL,FACU	NI*	1,2,3,4,5,6,7,8,9,0,A,C,H	AF
**Taraxacum officinale* Wigg.	FACU-,FACU+	FACU	1,2,3,4,5,6,7,8,9,0,A,C,H	PF
**Verbesina encelioides* (Cav.) A. Gray ssp. *exauriculata* Robinson & Greenman	FACU-,FAC	FAC	1,2,3,4,5,6,7,8,0	AF
**Xanthium spinosum* L.	FACU,FAC+	FAC+	1,2,3,4,5,6,7,8,9,0	AF
**Xanthium strumarium* L.	FAC-,FAC+	FAC+	1,2,3,4,5,6,7,8,9,0,C,H	AF

Bataceae—Saltwort Family
(1 native; no exotics)

Batis maritima L.	OBL	OBL	2,6,0,C,H	$F

Betulaceae—Birch Family **(1 native; no exotics)**				
Alnus rhombifolia Nutt.	FACW	FACW	8,9,0	T
Boraginaceae—Borage Family **(3 natives; no exotics)**				
Heliotropium curassavicum L.	FACW,OBL	OBL	1,2,3,4,5,6,7,8,9,0,C,H	P$F
Plagiobothrys acanthocarpus (Piper) I.M. Johnston	OBL	OBL	0	AF
Plagiobothrys nothofulvus (A. Gray) A. Gray	FAC	FAC	8,9,0	PF
Brassicaceae (Cruciferae)—Mustard Family **(6 natives; 6 exotics)**				
Arabis holboellii Hornem.	UPL,FACU	FACU*	3,4,5,7,8,9,0,A	BF
var. *pinetorum* (Tidestr.) Roll.				
Barbarea orthoceras Ledeb.	FACW,OBL	FACW	1,3,4,5,7,8,9,0,A	BPF
var. *orthoceras*				
**Cakile maritima* Scop.	FACU,FACW	FACW	1,2,9,0	A$F
**Capsella bursa-pastoris* (L.) Medikus	FACU,FAC	FAC-	1,2,3,4,5,6,7,8,9,0,H	AF
Cardamine californica (Torrey & A. Gray) E. Greene	UPL	UPL*	9,0	PF
**Cardamine oligsperma* Torrey & A. Gray	FACW	FACW	1,8,9,0,A	ABF
**Lepidium perfoliatum* L.	UPL,FAC	FACU	1,2,3,4,5,6,7,8,9,0	AF
Lepidium virginicum L.	UPL,FAC-	FACU	1,2,3,4,5,6,7,8,9,0,A,C,H	AF
var. *pubescens* (E. Greene) Thell.				
var. *robinsonii* (Thell.) C. Hitchc.				
**Rorippa nasturtium-aquaticum* (L.) Hayek	OBL	OBL	1,2,3,4,5,6,7,8,9,0,A,C,H	PZEF

Rorippa curvisliqua (Hook.) Britton	FACW,OBL	OBL	7,8,9,0,A	AEF
Rorippa palustris (L) Besser var *occidentalis* (S. Watson) Rollins	FAC,OBL	OBL	1,2,3,4,5,6,7,8,9,0,A,C	AEF
**Sisymbrium altissimum* L.	UPL,FAC	FACU	1,2,3,4,5,6,7,8,9,0,A,H	AF
Callitrichaceae—Water Starwort Family (1 native; no exotics)				
Callitriche marginata Torrey	OBL	OBL	9,0	AZF
Campanulaceae—Bellflower Family (3 natives; no exotics)				
Heterocodon rariflorum Nutt.	FACFACW	FACW*	8,9,0	AF
Lobelia dunnii E. Greene var. *serrata* (A. Gray) McVaugh	FACW-	FACW-	0	PF
Triodanis biflora (Ruiz Lopez & Pavon) E. Greene	UPL,FAC	FAC	1,2,3,4,5,6,7,8,9,0	AF
Cannabaceae—Hops Family (no natives; 1 exotic)				
**Cannabis sativa* L.	FACU-,FAC	FACU*	1,2,3,4,5,6,7,8,9,0	AF
Caprifoliaceae—Honeysuckle Family (1 native; 1 exotic)				
**Lonicera japonica* Thunb.	FACU,FAC+	NI	1,2,3,5,6,7,8,0,C	SWV
Sambucus mexicana C.Presl	FACU,FAC	FAC	6,7,8,0,H	ST

	Caryophyllaceae—Pink Family (2 natives; 2 exotics)			
**Cerastium fontanum* Baumg. ssp. *vulgare* (Hartman) Greuter & Burdet	FACU-,FAC-	FACU	1,2,3,4,5,6,7,8,9,0,A,H	PF
Spergularia macotheca (Hornem.) Heynh. var. *macrotheca*	FAC,FAC+	FAC+	9,0	PEF
Spergularia marina (L.) Griseb.	FACU,FACW	FACW*	1,3,7,8,9,0,H	AF
**Stellaria media* (L.) Villars	UPL,FACU	FACU	1,2,3,4,5,6,7,8,9,0,A,H	APF
	Ceratophyllaceae—Hornwort Family (1 native; no exotics)			
Ceratophyllum demersum L.	OBL	OBL	1,2,3,4,5,6,7,8,9,0,A,C,H	P/F
	Chenopodiaceae—Goosefoot Family (19 natives; 9 exotics)			
Atriplex argentea Nutt. var. *mohavensis* Jones	FACU,FAC	FAC	1,3,4,5,6,7,8,9,0	AF
Atriplex californica Moquin	FAC	FAC	0	PF
Atriplex canescens (Pursh) Nutt. ssp. *canescens*	UPL,FACU	FACU	4,5,6,7,8,9,0	S
Atriplex coulteri (Moquin) D. Dietr.	FACU	FACU	0	PF
Atriplex lentiformis (Torrey) S. Watson ssp. *lentiformis*	FAC,FACW	FAC	7,8,0	S
Atriplex leucophylia (Moquin) D. Dietr.	FAC	FAC*	0	H
Atriplex pacifica Nelson	FAC	FAC	0	AF
Atriplex parishii S. Watson	FAC	FAC	0	AF

Atriplex rosea L.	FACU-FACU+	FACU	1,3,4,5,6,7,8,9,0	AF
**Atriplex semibaccata* R. Br.	FAC,FACW	FAC	6,7,8,0,H	PF
Atriplex serenana Nelson	FAC	FAC	7,8,0	AF
var. *davidsonii* (Standley) Munz				
var. *serenana*				
Atriplex triangularis Willd.	FAC,FACW	FACW	1,2,3,4,5,6,7,8,9,0	AF
Atriplex watsonii Nelson	FACW+	FACW+	0	HS
**Bassia hyssopifolia* (Pallas) Kuntze	FAC,FACW	FAC	1,4,5,6,7,8,9,0,H	AF
**Beta vulgaris* L.	UPL,FACU	FACU	1,2,3,6,8,9,0,C	AF
**Chenopodium album* L.	FACU,FAC	FAC	1,2,3,4,5,6,7,8,9,0,A,H	AF
**Chenopodium ambrosiodes* L.	FACU,FAC	FAC	1,2,3,4,5,6,7,8,9,0,C,H	AF
**Chenopodium botrys* L.	UPL,FACU	FACU	1,2,3,4,5,6,7,8,9,0	AF
**Chenopodium murale* L.	FACU?	NO	H	AF
**Chenopodium rubrum* L.	FACW,OBL	NO	1,2,3,4,5,7,8,9,A	AF
Cycloloma atriplicifolium (Sprengel) J. Coulter	UPL,FAC	NI	1,2,3,4,5,6,7,8,9,0	AF
Monolepis nuttaliana (Schultes) E. Greene	UPL,FACW	FACW	1,2,3,4,5,6,7,8,9,0,A	AF
Nitrophila occidentalis (Nutt.) Moquin	FAC+,FACW	FACW	7,8,9,0	PF
Salicornia bigelovii Torrey	OBL	OBL	1,2,6,7,0	AE$F
Salicornia subterminalis Parish	OBL	OBL	0	PE$F
Salicornia virginica L.	OBL	OBL	1,2,6,7,9,0,C,H	PE$H
Suaeda calceoliformis (Hook.) Moquin	FACW-,FACW+	FACW+	1,3,4,5,6,7,8,9,0,A	APF
Suaeda moquinii (Torrey) E. Greene	FAC,FACW-	FAC+	5,6,7,8,9,0	EH
Suaeda taxifolia (Standley) Standley	FACW+	FACW+	0	EH

	Convulvulaceae—Morning Glory Family **(2 natives; 1 exotic)**			
Calystegia sepium (L.) R. Br. ssp. *binghamiae* (E. Greene) Brummitt	FACU, OBL	OBL	1,2,3,4,5,6,7,8,9,0	PF
Cressa truxillernsis Kunth	FACW-,FACW	FACW	6,7,8,9,0	PF
**Ipomoea purpuea* (L.) Roth	UPL,FAC	FAC	1,2,3,4,5,6,7,8,0,C	AV
	Crassulaceae—Stonecrop Family **(2 natives; no exotics)**			
Crassula connata (Ruiz Lopez & Pavon) Berger var. *erectoides* Bywater & Wilkens	UPL,FACW	FAC	7,9,0	A$F
Crassula aquatica (L.) Schonl.	OBL	OBL	1,2,3,6,7,8,9,0,A	A$F
	Datiscaceae—Datisca Family **(1 native; no exotics)**			
Datisca glomerata (C. Presl) Baillon	FACW	FACW	8,0	PF
	Elatinaceae—Waterwort Family **(2 natives ; no exotics)**			
Elatine brachysperma A. Gray	FACW,OBL	FACW	1,2,3,6,7,8,9,0	AE/F
Elatine califonica A. Gray	OBL	OBL	7,9,0	AEF
	Euphorbiaceae—Spurge Family **(no natives; 2 exotics)**			
**Chamaesyce nutans* (Lagasca) Small	UPL,FACU	FACU*	1,2,3,4,5,6,7,8,9,0	AF
**Ricinus communis* L.	UPL,FAC-	FACU	1,2,3,5,6,7,8,0,C,H	APFS

Fabaceae (Leguminosae)-Pea Family
(11 natives; 11 exotics)

Amorpha californica Nutt.	FACU,FAC	FACU	7,0	S
Amorpha fruticosa L.	FAC,OBL	FAC*	1,2,3,4,5,6,7,8,0	S
Astragalus pycnostachyus A. Gray var. *lanosissimus* (Rydb.) Munz (EXTINCT)	OBL	OBL	0	PF
*Gledisia *triacanthos* L.	FACU,FAC	NO	1,2,3,4,5,6,7,8,9	T
Glycyrrhiza lepidota Pursh	UPL,FAC+	FAC+	1,2,3,4,5,6,7,8,9,0	PF
Hoita macrostachya (DC.) Rydb.	OBL	OBL	0	PF
Hoita orbicularis (Lindley) Rydb.	OBL	OBL	0	PF
**Lotus corniculatis* L.	FACU-FAC	FAC	1,2,3,4,5,6,7,9,0	PF
**Medicago lupulina* L.	UPL,FAC	FAC	1,2,3,4,5,6,7,8,9,0,A,H	AF
**Melilotus alba* Medikus	FACU-,FACU+	FACU+	1,2,3,4,5,6,7,8,9,0,A,C,H	ABF
**Melilotus indica* (L.) All.	FACU-FAC	FAC	1,2,3,6,7,8,9,0,H	AF
**Parkinsonia aculeata* L.	FAC-,FACW	FACW*	2,6,7,8,0,C	T
**Robinia pseudoacacia* L.	UPL,FAC	FAC*	1,2,3,4,5,6,7,8,9,0	T
Trifolium depauperatum Desv. var. *truncatum* (E. Greene) Isely	FAC-	FAC-	3,9,0	AF
**Trifolium fragiferum* L.	FACUFACW-	NI*	1,2,3,4,5,8,9,0	PF
Trifolium microphalum Pursh	FACU,FACW	FACU*	7,8,9,0,A	AF
Trifolium obtusiflorum Hook. & Arn.	FAC	FAC*	9,0	AF
**Trifolium pratense* L.	FACU-FAC	FACU+	1,2,3,4,5,6,7,8,9,0,A,C,H	BPF
**Trifolium repens* L.	FACU-FAC	FACU+	1,2,3,4,5,6,7,8,9,0,A	PF
Trifolium wormskioldii Lehm.	FAC,OBL	FACW	6,7,8,9,0,A	PF
Vicia americana Wild. var. *americana*	FAC?	NI	1,2,3,4,5,6,7,8,9,0,A	PFV

**Vicia sativa* L. ssp. *sativa*	UPL,FACW	FACU	1,2,3,4,5,6,7,8,9,0,A,H	AFV
Fagaceae—Oak Family **(1 native; no exotics)**				
Quercus lobata Nee.	FAC	FAC*	0	T
Frankeniaceae—Frankenia Family **(1 native; no exotics)**				
Frankenia salina (Molina) I.M. Johnston	FACW+	FACW+	0,H	HS
Gentianaceae—Gentian Family **(1 native; no exotics)**				
Eustoma exaltatum (L.) Don	FACW,OBL	OBL*	2,6,7,0,C	APF
Grossulariaceae—Gooseberry Family **(1 native; no exotics)**				
Ribes aureum Pursh var. *gracillimum* (Cov. & Britton) Jepson	FAC-,FACW	FACW	3,6,7,8,9,0	S
Juglandaceae—Walnut Family **(1 native; no exotics)**				
Juglans californica S. Watson	FAC	FAC	0	T

Lamiaceae (Labiatae)—Mint Family
(3 natives; 2 exotics)

Lycopus americanus W.C. Barton	OBL	OBL	1,2,3,4,5,6,7,8,9,0	PF
**Marrubium vulgare* L.	UPL,FACW-	FAC	1,2,3,4,5,6,7,8,9,0,A	PF
**Mentha spicata* L. var. *spicata*	FACW,OBL	OBL	1,2,3,4,5,6,7,8,9,0,A	PF
Stachys ajugoides Benth. var. *ajugoides*	OBL	OBL	0	PF
var. *rigida* Jepson & Hoover	FAC,FACW+	FACW+	8,9,0	PF

Lauraceae—Laurel Family
(1 native; no exotics)

Umbellularia californica (Hook. & Arn.) Nutt.	FAC-,FAC	FAC	9,0	T

Lythraceae—Loosestrife Family
(3 natives; no exotics)

Ammannia coccinea Rottb.	FACW+,OBL	OBL	1,2,3,4,5,6,7,8,9,0,C,H	AF
Lythrum californicum Torrey & A. Gray	OBL	OBL	5,6,7,8,0	PF
Lythrum hyssopifolia L.	FACW,OBL	FACW	1,3,9,0	ABF

Malvaceae—Mallow Family
(1 native; 1 exotic)

**Abutilon theophrasti* Medikus	UPL,FACU-	NI	1,2,3,4,5,6,7,8,0	AF
Sidalcea neomexicana A. Gray	FACW	FACW	6,7,8,9,0	PFH

Molluginaceae—Carpet-weed Family **(no natives; 1 exotic)**				
**Mollugo verticillata* L.	FAC-,FAC	FAC	1,2,3,4,5,6,7,8,9,0,C	AF
Myrtaceae—Myrtle Family **(no natives; 1 exotic)**				
**Eucalyptus camaldulensis* Dehnh.	FAC?	NO	H,C,O	T
Oleaceae—Olive Family **(5 natives; 1 exotic)**				
Fraxinus velutina Torrey	FAC,FACW	FACW	6,7,8,0	T
Onagracee—Evening-Primrose Family **(4 natives; 1 exotic)**				
Epilobium ciliatum Raf. ssp. *ciliatum*	FACU,OBL	FACW	1,2,3,4,5,6,7,8,9,0,A,H	PF
Epilobium densiflora (Lindlley) P. Hoch & Raven	FACW-,OBL	OBL	7,8,9,0	AF
**Gaura parviflora* Douglas	FACU?	NI	1,2,3,4,5,6,7,8,9,0	AF
Ludwigia peploides (Kunth) Raven	OBL	OBL	1,2,3,5,6,7,0,C	PE/F
Oenothera elata Kunth ssp. *hirsutissima* (S. Watson) W. Dietr.	FACU-,FACW	FACW	1,2,3,4,5,6,7,8,9,0	BPF
Oxalidaceae—Oxlis Family **(no natives; 1 exotic)**				
**Oxalis corniculata* L.	UPL,FACU	FACU	1,2,3,4,5,6,7,8,9,0,C,H	PF

	Phytolaccaceae—Pokeweed Family (no natives; 1 exotic)			
**Phytolacca americana* L.	FACU+,FAC	NI	1,2,3,5,6,7,9,0	PF
	Plantaginaceae—Plantain Family (3 natives; 3 exotics)			
Plantago elongata Pursh	OBL	OBL	9,0	PF
**Plantago lanceolata* L.	UPL,FAC	FAC-	1,2,3,4,5,6,7,8,9,0,A,C,H	PBF
**Plantago major* L.	FACU,FACW	FACW-	1,2,3,4,5,6,7,8,9,0,A,C,H	PAF
Plantago ovata Forsskal	UPL,FAC	FACU	6,7,8,0	AF
Plantago subnuda Pilger	FACW,OBL	FACW+	7,9,0	PF
**Plantago virginica* L.	UPL,FAC+	UPL	1,2,3,5,6,7,0	ABF
	Platanaceae—Sycamore Family (1 native; no exotics)			
Platanus racemosa Nutt.	FACW	FACW	0	T
	Polemoniaceae—Phiox Family (3 natives; no exotics)			
Linanthus floribundus (A. Gray) Milliken	UPL,FAC	UPL	7,8,9,0	PF
Navarretia prostrata A. Gray	OBL	OBL	O	AF
Phlox gracilis E. Greene	UPL,FAC-	FACU*	3,4,5,6,7,8,9,0,A	AF

Polygonaceae—Buckwheat Family
(6 natives; 6 exotics)

Polygonum amphibium L. var. *emersum* Michaux	OBL	OBL	1,2,3,4,5,6,7,8,9,0,A	PE/F
**Polygonum arenastrum* Boreau	UPL,FACW	FAC	1,2,3,4,5,6,7,8,9,0,A,H	APF
**Polygonum argyrocoelon* Kunze	FAC,OBL	FAC+	1,2,6,7,8,0	AF
Polygonum hydropiperoides Michaux	OBL	OBL	1,2,3,4,5,6,7,8,9,0,A,C	PEF
Polygonum lapathifoliaum L.	FAC,OBL	OBL	1,2,3,4,5,6,7,8,9,0,A	AF
Polygonum punctatum Elliott	FACW, OBL	OBL	1,2,3,4,5,6,7,8,9,0,C,H	AP$F
**Polygonum persicaria* L.	FAC,OBL	FACW	1,2,3,4,5,6,7,8,9,0,A,H	AF
**Rumex acetosella* L.	UPL,FACW	FAC-	1,2,3,4,5,6,7,8,9,0,A,H	PF
**Rumex conglomeratus* Murray	FAC,FACW	FACW	1,2,3,6,7,8,9,0	PF
**Rumex crispus* L.	FACU,FACW	FACW-	1,2,3,4,5,6,7,8,9,0,A,C,H	PF
Rumex maritimus L.	FACW-,OBL	OBL	1,2,3,4,5,6,7,8,9,0,A	ABF
Rumex salicifolius J.A. Weinm.	FAC,OBL	OBL	3,8,9,0,A	PF

Portulacaceae—Pursiane Family
(2 natives; 1 exotic)

Calandrinia ciliata (Ruiz Lopez & Pavon) DC.	FACU	FACU*	7,8,9,0	A$F
Claytonia perfoliata Willd. ssp. *mexicana* (Rydb.) John M. Miller & Chambers ssp. *perfoliata*	FAC-FACW	FAC	4,7,8,9,0,A	AF
**Portulaca oleracea* L.	FACU,FAC	FAC	1,2,3,4,5,6,7,8,9,0,C,H	A$F

	Primulaceae—Primrose Family **(1 native; 1 exotic)**			
**Anagallis arvensis* L.	UPL,FACW-	FAC	1,2,3,4,5,6,7,8,9,0	AF
Samolus parviflorus Raf.	OBL	OBL	1,2,3,5,6,7,8,0	PF
	Ranunculaceae— Buttercup Family **(4 natives; no exotics)**			
Clematis ligusticifolia Nutt.	FACU,FACW	FAC	1,2,4,5,6,7,8,9,0	WV
Ranunculus aquatilus L. *var. *capillaceus* (Thuill.) DC.	OBL	OBL	1,2,3,4,5,6,7,8,9,0,A	PZF
Ranunculus californicus Benth.	FAC	FAC	9,0	PF
Ranunculus cymbalaria Pursh var. *saximontanus* Fern.	OBL	OBL	1,3,4,5,6,7,8,9,0,A	PEF
	Rosaceae—Rose Family **(2 natives; no exotics)**			
Potentilla glandulosa Lindley ssp. *glandulosa* ssp. *reflexa* (E. Greene) Keck	FACU,OBL	FAC	4,7,8,9,0	PFH
Rosa californica Cham. & Schldl.	FAC+	FAC+	9,0	S
	Rubiaceae—Madder Family **(no natives; 1 exotic)**			
**Galium aparine* L.	FACU,FAC-	FACU	1,2,3,4,5,6,7,8,9,0,A	AF

	Salicaceae—Willow Family **(4 natives; no exotics)**			
Populus fremontii S. Watson ssp. *fremontii*	FACW-,FACW	FACW	6,7,8,0	T
Salix gooddingii Ball	FACW,OBL	OBL	6,7,8,0	T
Salix lasiolepsis Benth.	FACW	FACW	0+?	S
Salix lucida Muhlenb. ssp. *lasiandra* (Benth.) E. Murray	FACW	FACW	6,7,8,9,0	S
	Saururaceae—Lizard's-Tall Family **(1 native; no exotics)**			
Anemopsis californica (Nutt.) Hook. & Arn.	FACW+,OBL	OBL	5,6,7,8,9,0	PF
	Saxifragaceae—Saxifrage Family **(1 native; no exotics)**			
Boykinia rotundifolia C. Parry	FACW	FACW	0	AF
	Scrophulariaceae—Figwort Family **(7 natives; 2 exotics)**			
Castilleja minor (A. Gray) A. Gray ssp. *spiralis* (Jepson) Chuang & Heckard	OBL	OBL	0	AF
Cordylanthus maritimus Benth. ssp.maritimus	OBL	OBL	8,9,0	A+F
**Kickxia elatine* (L.) Dumort.	UPL,FAC	NI*	1,2,3,5,6,9,0,C	AF
Mimulus cardinalis Benth.	FACW,OBL	OBL	7,8,9,0	PF
Mimulus floribundus Lindley	FACW+,OBL	OBL	2,4,5,7,8,9,0	AF

Mimulus guttatus DC.	OBL	OBL	1,4,5,7,8,9,0,A	AF
Scrophularia californica Cham. & Schldl var. *floribundus* (E. Greene) Shaw	FAC,FACW-	FAC	7,9,0	PF
**Veronica anagallis-aquatica* L.	OBL	OBL	1,2,3,4,5,6,7,8,9,0,A	PEF
Veronica peregrina L. ssp. *xalapensis* (Kunth) Pennell	FACU-,OBL	OBL	1,2,3,4,5,6,7,8,9,0,A,C	AEF

Simaroubaceae—Quassia Family
(no natives, 1 exotic)

**Ailanthus altissima* (Miller) Swingle	FACU	FACU	1,2,3,5,6,7,8,9,0	T

Solanaceae—Nightshade Family
(4 natives; 4 exotics)

Nicotiana attenuata Torrey	UPL,FAC	FAC	7,8,9,0	AF
**Nicotiana glauca* Graham	FAC	FAC	2,6,7,8,0,H	ST
Nicotiana quadrivalvis Pursh	FACU,FAC	FAC	8,9,0	AF
Petunia parviflora A.L. Juss.	FAC,FACW	FACW	1,2,6,7,0	AF
**Physalis philadelphica* Lam.	UPL,FAC	FAC	1,2,3,5,7,9,0	AF
**Solanum americanum* Miller	FACU-,FAC	FAC	1,2,3,4,5,6,7,9,0,C	AF
Solanum douglasii Dunal	FACU,FAC	FAC	2,6,7,9,0	PF
**Solanum nigrum* L.	FACU-,FACU+	FACU	1,2,3,4,5,6,7,8,9,0,A,C,H	AF

Tamaricaceae—Tamarisk Family
(no natives; 2 exotics)

**Tamarix chinensis* Lour.	FACW	FACW	2,4,5,6,7,8,9,0	T
**Tamarix ramosissima* Ledeb.	FAC,FACW	FAC	1,2,4,5,6,7,8,9,0	T

Urticaceae—Nettle Family
(2 natives; no exotics)

Parietaria hespera B.D. Hinton	FAC-	NI	1,2,6,7,8,0	AF
Urtica dioica L. ssp. *holosericea* (Nutt.) Thorne	FACU,FACW	FACW	1,2,3,4,5,6,7,8,9,0,A	PF

Valerianaceae—Valerian Family
(1 native; no exotics)

Plectritis ciliosa (E. Greene) Jepson ssp. *insignis* (Suskd.) Morey	FACU,FAC	FACU	7,9,0	AF

Verbenaceae—Vervain Family
(4 natives; no exotics)

Verbena bracteata Lagasca & J.D. Rodriguez	UPL,FACW	FACW	1,2,3,4,5,6,7,8,9,0	APF
Verbena lasiostachys Link. var. *lasiostachys* Link	FAC-	FAC-	1,9,0,H	PF
var. *scabrida* Mold.	FACW	FACW	0	PF
Verbena scabram M. Vahl	FACW,OBL	OBL	1,2,6,7,0,C	PEFS

MONOCOTYLEDONES (Liliopsida)—Monocots

Alismataceae—Water-Plantain Family
(2 natives; no exotics)

Sagittaria latifolia Willd.	OBL	OBL	1,2,3,4,5,6,7,8,9,0,H	PEF
Sagittaria sanfordii E. Greene	OBL	OBL	0	PEF

	Araceae—Arum Family (no natives; 1 exotic)			
**Zantedeschia aethiopica* (L.) K.Sprengel	OBL	OBL	0,C	PF
	Cyperaceae—Sedge Family (28 natives; 3 exotics)			
Carex barbarae Dewey	FAC+,FACW	FACW	9,0	PGL
Carex praegracilis W. Boott	FACW-,FACW	FACW-	1,3,4,5,6,7,8,9,0,A	PGL
Carex schottii Dewey	OBL	OBL	0	PGL
Carex senta W. Boott	OBL	OBL	7,8,0	PGL
Carex spissa L. Bailey	FAC	FAC*	7,0	PGL
Cyperus acuminatus Torrey & Hook.	OBL	OBL	1,2,3,4,5,6,7,8,9,0	ABPGL
Cyperus bipartitus Torrey	FACW,FACW+	FACW+	5,6,7,9,0	PEGL
Cyperus eragrostis Lam.	FACW	FACW	1,2,9,0	PEGL
Cyperus erythrorhizos Muhlenb.	FACW+,OBL	OBL	1,2,3,4,5,6,7,8,9,0	APEGL
Cyperus esculentus L.	FAC,FACW	FACW	1,2,3,4,5,6,7,8,9,0,C	PGL
**Cyperus involucratus* Rottb.	FACW+,OBL	OBL	1,2,6,0,C,H	PIGL
Cyperus laevigatus L.	FAC,FACW+	FACW+	2,6,7,8,0,C,H	PGL
Cyperus niger Ruiz Lopez & Pavon	FACW,FACW+	FACW+	5,6,7,9,0	PEGL
Cyperus odoratus L.	FACW,FACW+	FACW	1,2,3,4,5,6,7,0,C,H	APGL
**Cyperus papyrus* L.	OBL	NO	2,H	PGL
**Cyperus rotundus* L.	FAC-,FAC	FAC	1,2,3,6,7,0,C,H	PIGL
Cyperus squarrosus L.	FACW+,OBL	OBL	1,2,3,4,5,6,7,8,9,0	AGL
Eleocharis acicularis (L.) Roemer & Schultes	OBL	OBL	1,2,3,4,5,6,7,8,9,0,A,H	PEGL
Eleocharis macrostachya Britton	OBL	OBL	1,2,3,4,5,6,7,8,9,0,A	PEGL
Eleocharis montevidensis Kunth	FACW,FACW+	FACW	2,5,6,7,0	PGL

Eleocharis parvula (Roemer & Schultes) Link	OBL	OBL	1,2,3,4,5,6,7,8,9,0	PGL
Eleocharis rostellata Torrey (Torrey)	OBL	OBL	1,2,3,4,5,6,7,8,9,0,C	PGL
Scirpus acutus Muhlenb. var. *occidentalis* (S. Watson) Beetle	OBL	OBL	1,2,3,4,5,6,7,8,9,0,A	PEGL
Scirpus americanus Pers.	OBL	OBL	1,2,3,4,5,6,7,8,9,0,A,C,H	PEGL
Scirpus californicus (C. Meyer) Steudel	OBL	OBL	2,6,7,0,H	PEGL
Scirpus cernuus Vahl.	OBL	OBL	2,9,0	AGL
Scirpus koilolepis (Steudel) Gleason	FACW+,OBL	OBL	1,2,3,5,6,0	AGL
Scirpus maritimus L.	OBL	OBL	1,2,3,4,5,6,7,8,9,0,A,H	PEGL
Scirpus microcarpus C. Presl	OBL	OBL	1,2,3,4,5,7,8,9,0,A	PEGL
Scirpus pungens Vahl	FACW+,OBL	OBL	1,2,4,5,6,7,8,9,0	PEGL
Scirpus robustus Pursh	OBL	OBL	1,2,6,0	PEGL

Hyrocharitaceae—Waterweed Family
(1 native; no exotics)

Najas guadalupensis (Sprengel) Magnus	OBL	OBL	1,2,3,4,5,6,7,8,9,0,C	AZF

Iridaceae—Iris Family
(1 native; no exotics)

Sisyrinchium bellum S. Watson	FAC,FACW-	FAC	9,0	PF

Juncaceae—Rush Family
(12 natives; no exotics)

Juncus acutus L. ssp. *leopoldii* (Parl.) Snog.	FACW,FACW+	FACW	7,8,0	PGL
Juncus balticus Willd.	FACW,OBL	OBL	1,2,3,4,5,6,7,8,9,0,A,H	PGL

Juncus bufonius L. var. *bufonius*	FACW,OBL	FACW+	1,2,3,4,5,6,7,8,9,0,A,H	AGL
Juncus macrophyllus Cov.	FACW	FACW*	7,8,0	PGL
Juncus mexicanus Willd.	FACW	FACW	6,7,8,0	PGL
Juncus oxymeris Engelm.	FACW,FACW+	FACW	9,0	PGL
Juncus patens E. Meyer	FAC, FACW	FAC	9,0	PGL
Juncus phaeocephalus Engelm var. *paniculatus* Engelm.	FACW	FACW	9,0,H	PGL
Juncus rugulosus Engelm.	OBL	OBL	0	PGL
Juncus textilis Buchenau	OBL	OBL	0	PGL
Juncus torreyi Cov.	FACW,FACW+	FACW+	1,2,3,4,5,6,7,8,9,0	PGL
Juncus xiphioides E. Meyer	OBL	OBL	7,8,9,0,H	PGL

Juncaginaceae—Arrow-Grass Family
(1 native; no exotics)

Triglochin concinna Burtt Davy var. *concinna*	OBL	OBL	4,7,8,9,0	PF

Lemnaceae—Duckweed Family
(3 natives; no exotics)

Lemna minor L.	OBL	OBL	1,2,3,4,5,6,7,8,9,0,A,H	P/F
Lemna valdiviana Philippi	OBL	OBL	1,2,3,4,5,6,7,8,9,0,	P/F
Wolffiella lingulata (Hegelm.) Hegelm.	OBL	OBL	2,6,0,C	P/F

Lilaceae—Lily Family **(no natives; 1 exotic)**				
**Asparagus officinalis* L. ssp. *officinalis*	FACU-,FACU	FACU	1,2,3,4,5,6,7,8,9,0	PF
Ordchidaceae—Orchid Family **(2 natives; no exotics)**				
Epipactis gigantea Hook.	FACW+,OBL	OBL	4,6,7,8,9,0	PF
Piperia unalascensis (Sprengel) Rydb.	UPL,FAC	FAC	3,4,8,9,0,A	PF
Poaceae (Gramineae)—Grass Family **(21 natives; 37 exotics)**				
Agrostis exarata Trin.	FACW	FACW	4,5,6,7,8,9,0,A	PG
**Agrostis stolonifera* L.	FAC+,FACW	FACW	1,2,3,4,5,6,7,8,9,0,A,H	PG
**Agrostis viridis* Gouan	FACW,OBL	OBL	1,5,6,7,8,9,0,H	PG
**Alopecurus pratensis* L.	FAC,FACW	FACW	1,2,3,4,5,6,8,9,0,A	PG
Andropogon glomeratus (Walter) Britton, Stevens & Pogg var. *scabriglumis* C.S. Campbell	FACW,OBL	FACW	1,2,5,6,7,8,0,C,H	PG
**Arundo donax* L.	FACU-,FACW	FACW	1,2,3,6,7,8,0,C,H	PG
**Bromus hordeaceus* L.	UPL,FACU-	FACU-	1,2,3,4,5,6,7,8,9,0,A	AG
**Bromus madritensis* L. ssp. *rubens* (L.) Husnot	FACU?	NI	1,6,7,8,9,0	AG
**Cenchrus echinatus* L.	FACU?	NO	H	AG
**Crypsis schoenoides* (L.) Lam	FACU,OBL	OBL	1,3,8,0	AG
**Crypsis vaginiflora* (Forsskal) Opiz	OBL	OBL	9,0	AG
**Cynodon dactylon* (L.) Pers.	FACU,FAC	FAC	1,2,3,5,6,7,8,9,0,C,H	PG

**Dactylis glomerata* L.	FACU,FACU+	FACU	1,2,3,4,5,6,7,8,9,0,A,C,H	PG
**Digitaria ciliaris* (Retz) Koel.	FAC?	NO	H	AG
**Digitaria sanguinalis* (L.) Scop.	FACU-,FAC-	FACU	1,2,3,4,5,6,7,8,9,0,C,H	AG
Diplachne uninervia (Presl) Parodi.	FACW-,FACW	FACW	1,2,6,7,8,9,0,C,H	AG
Distichlis spicata (L.) E. Greene	FAC+,FACW+	FACW	1,2,3,4,5,6,7,8,9,0	PG
**Echinochloa crus-galli* (L.) Beauv. var. *crus-galli*	FACU,FACW	FACW	1,2,3,4,5,6,7,8,9,0,C,H	AG
Elymus glaucus Buckley ssp. *glaucus*	FACU	FACU	1,2,3,4,7,8,9,0,A	PG
Elymus trachycaulus (Link) Shinn. ssp. *trachycaulus*	FACU,FACW	NI*	1,2,3,4,5,6,7,8,9,0,A	PG
**Eragrostis cilianensis* (All.) Janchen	FACU,FACU+	FACU	1,2,3,4,5,6,7,8,9,0,H	AG
Eragrostis mexicana (Hornem.) Link.	UPL,FAC	FAC	1,2,3,6,7,0	AG
ssp. *mexicana*				
ssp. *virescens* (C. Presl.) S.D. Koch & E. Sanchez				
**Eragrostis pilosa* (L.) Beauv. var. *pilosa*	FACU	FACU	1,2,3,4,5,6,7,8,9,0,C,H	AG
**Festuca arundinacea* Schreber	UPL,FACW-	FAC-	1,2,3,4,5,6,7,8,9,0,A	PG
Festuca rubra L.	FACU,FACW-	FAC	1,2,3,5,6,7,8,9,0,A	PG
**Gastridium ventricosum* (Gouan) Schinz &Thell.	FACU	FACU	1,6,7,9,0	AG
**Hainardia cylindrica* (Willd.) Greuter	UPL,FACW+	FACW+	0+?	AG
Hordeum brachyantherum Nevski	FAC,FACW	FACW	1,2,3,7,8,9,0,A	PG
Hordeum depressum (Scribner & J.G. Smith) Rydb.	NI	NI	9,0	AG

**Hordeum murinum* L. ssp. *leporinum* (Link) Archang.	FACU?	NI	1,26,7,8,9,0	AG
Leymus condensatus (C. Presl) A. Löve	FACU	FACU	3,9,0	PG
Leymus triticoides (Buckley) Pilger	FACU,FAC+	FAC+	6,7,8,9,0	PG
**Lolium perenne* L.	FACU-,FAC	FAC*	1,2,3,4,5,6,7,8,9,0,A,C	PG
Monanthochloe littoralis Engelm.	OBL	OBL	2,6,0	PEG
Muhlenbergia rigens (Benth.) A. Hitchc.	UPL,FACW	FACW	6,7,8,0	PG
Panicum capillare L.	FACU,FAC	FAC	1,2,3,4,5,6,7,8,9,0,C	AG
**Parapholis incurva* (L.) C.E. Hubb.	FAC,OBL	OBL	1,2,6,9,0	AG
**Paspalum dilatatum* Poiret	FAC,FAC+	FAC	1,2,6,7,9,0,C.H	PG
**Paspalum paspalodes* (Michx.) Scribn.	FACW,OBL	OBL	1,2,5,6,7,8,9,0,C,H	PEG
**Pennisetum clandestinum* Chiov.	FACU+	FACU+	O,H	PG
**Phalaris aquatica* L.	FAC+,FACW+	FAC+	2,6,7,9,0	PG
**Poa annua* L.	FACU,FACW-	FACW-	1,2,3,4,5,6,7,8,9,0,A,C,H	AG
Poa fendleriana (Steudel) Vasey ssp. *longiligula* (Scribner) Williams	UPL,FACU	FACU*	4,5,6,7,8,9,0	PG
**Poa pratensis* L. ssp. *pratensis*	FACU,FAC-	FACU	1,2,3,4,5,6,7,8,9,0,A,C,H	PG
**Polypogon interruptus* Kunth	FACW,OBL	OBL	2,5,6,7,8,9,0,H	PG
**Polypogon monspeliensis* (L.) Desf.	FACW,OBL	FACW+	1,2,3,4,5,6,7,8,9,0,A,H	AG
Setaria gracilis Kunth	FAC	FAC	1,2,3,5,6,7,8,9,0,C	PG
**Setaria sphacelata* (Schumacher) Stapf & C.E. Hubb.	OBL	OBL	2,0	PG
**Setaria verticillata* (L.) P. Beauv.	FACU,FAC	NI*	1,2,3,4,5,6,7,8,9,0,H	AG
**Sorghum bicolor* (L.) Moench	UPL,FAC	FAC*	1,2,3,4,6,7,8,0,C,H	AG
**Sorghum halepense* (L.) Pers.	FACU,FACU+	FACU	1,2,3,4,5,6,7,8,9,0,C,H	PG

Spartina foliosa Trin.	OBL	OBL	0	PG
Sporobolus airoides (Torrey) Torrey	FAC-,FAC+	FAC+	1,3,4,5,6,7,8,9,0	PG
Sporobolus flexuosus (Vasey) Rydb.	UPL,FAC-	UPL	5,6,7,8,0	PG
**Stenotaphrum secundatum* (Walter) Kuntze	FAC,FAC+	FAC+	1,2,6,0,C	PG
**Vulpia bromoides* (L.) S.F. Gray	UPL,FACW	FACW	1,2,3,6,9,0,C,H	AG
**Vulpia myuros* (L.) C. Gmelin	UPL,FACW	FACW*	1,2,3,5,6,7,8,9,0,A,H	AG
*var. *hirsuta* (Hackel) Asch & Graebner				
*var. *myuros*				
Vulpia octoflora (Walter) Rydb.	UPL,FACU+	UPL	1,2,3,4,5,6,7,8,9,0,H	AG
var. *hirtella* (Piper) Hernard				
var. *octoflora*				

Pontederiaceae—Pickerel-Weed Family
(no natives; 1 exotic)

**Eichornia crassipes* (C. Martius) Solms Laubach	OBL	OBL	1,2,3,6,7,0,C,H	PE/F

Potamogetonaceae—Pondweed Family
(4 natives; 1 exotic)

**Potamogeton crispus* L.	OBL	OBL	1,2,3,4,5,6,7,8,9,0	PZF
Potamogeton nodosus Poiret	OBL	OBL	1,2,3,4,5,6,7,8,9,0,C,H	P/F
Potamogeton pectinatus L.	OBL	OBL	1,2,3,4,5,6,7,8,9,0,A,H	PZF
Ruppia cirrhosa (Petagna) Grande	UPL,OBL	OBL	9,0,A	PZF
Ruppia maritima L.	OBL	OBL	1,2,3,4,5,6,7,8,9,0,A,C,H	PZF

Typhaceae—Cattail Family
(3 natives; no exotics)

Typha angustifolia L.	OBL	OBL	1,2,3,4,5,6,7,8,9,0,C	PEF
Typha domingensis Pers.	OBL	OBL	1,2,5,6,7,8,9,0,C	PEF
Typha latifolia L.	OBL	OBL	1,2,3,4,5,6,7,8,9,0,A,H	PEF

Zannichelliaceae—Horned Pondweed Family
(1 native; no exotics)

Zannichellia palustris L.	OBL	OBL	1,2,3,4,5,6,7,8,9,0,A	PZF

Zosteraceae—Eel-Grass Family
(3 natives; no exotics)

Phyllospadix scouleri Hook.	OBL	OBL	9,0	PZF
Phyllospadix torreyi S. Watson	OBL	OBL	9,0	PZF
Zostera marina L.	OBL	OBL	1,2,9,0,A	PZF

Book Review

Torrey Pines: Landscape and Legacy by Bill Evarts, 1994. 86 pages. Torrey Pines Association, La Jolla, California. Cloth (ISBN 0-9629917-1-6) $27.95. Paper (ISBN 0-9629917-2-4) $17.95.

This marvelous book, produced by Cachuma Press, the publisher of Oaks of California (an equally beautiful book), features the rarest pine species in the world, *Pinus torreyana*. Torrey Pines are found only in the Torrey Pines State Reserve near Del Mar and on Santa Rosa Island. It has been estimated that the entire species is represented by no more than 10,000 trees, which is the basis for ranking this as the rarest of pine species.

Bill Evarts is a self-taught nature photographer who apparently has put his heart and soul into this, his first book. It took him seven years to put it together, but the product is an exquisite photographic essay. Essentially this is a picture book, although the text, while limited in scope, is accurate and informative.

In the Preface, Bill Evarts credits naturalist Guy Fleming for activating his interest, while he was a child, in the enchanted place called Torrey Pines State Reserve. The reserve, rather than the tree, is the major subject of the book, although, Mr. Evarts also documents the life history of the Torrey Pine.

There are four chapters. Chapter One: “Sparing the Tree”, documents the discovery of the species and the decades-long battle to save the site from development. Chapter Two: “A Spirit Captured”, is a description of the species and a review of the hypotheses for the unique distribution of the species. Chapter Three: “Itself, Alone, Unimitated”, describes the climate, plant communities, and archeology of the reserve. Chapter Four: "Whose Heritage It Is," discusses various philosophies of preservation, including controversies over grazing and fire ecology. In the Afterword, John Shelton of the Torrey Pines Association summarizes an important aspect of this type of book. He states “Never before has so much of the essence of Torrey Pines been captured between the covers of a single volume. We come away realizing that, by force of circumstances, we are custodians of one of the rarest remnants of natural open space in the world. And that, unlike Yosemite or the Grand Canyon whose principal assets are carved in enduring stone, Torrey Pines is fragile within and vulnerable from without. The implications are clear.”

Pick up a copy of this book. Thumb through its pages, enjoying its exquisite photographs, and be ever-thankful that we live in California, one of the most beautiful places on earth.

Allan A. Schoenherr, Fullerton College

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Postfire Reproduction of *Croton californicus* (Euphorbiaceae) and Associated Perennials in Coastal Sage Scrub of Southern California

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Abstract

Postfire regeneration of *Croton californicus* and associated perennials in a coastal sage scrub community was studied at 1.5 and 2.5 years postburn. Reproduction and vegetative growth of *Lotus scoparius* and *C. californicus* were significantly stimulated in the burn area while the preburn dominants *Eriodictyon trichocalyx*, *Eriogonum fasciculatum*, *Senecio flaccidus*, and *Opuntia littoralis* were significantly reduced after fire. *Croton californicus* increased in density and cover approximately three times and eight times that of the control at 1.5 years and 2.5 years postburn respectively. The insignificant difference between burn and control crown diameters at 1.5 years postburn indicates that *Croton* resprouts following fire (resprouting was observed in another burn at 0.5 years postburn with a resprouting rate of 68.8%). A major portion of the postburn density was derived from first, second, and third season seedlings. There was significantly more new seedlings germinating in the burn area when compared to the control area during the third postburn season, with 57% of the burn seedlings occurring in rodent disturbed soils.

Postburn *C. californicus* population patterns of sex expression were not greatly affected by the fire. Female plants were more numerous than male plants in both the burn and control areas with a total male:female sex ratio of 0.90. Female biased sex ratios were slightly less pronounced in the burn area especially at 1.5 years postburn. Male plants were significantly larger than female plants for crown diameter regardless of postburn time. Both sexes in the burn area had exceeded the mean crown diameters of the control area by 2.5 years postburn.

Introduction

Croton californicus Muell. Arg. is a subshrub that inhabits sandy soils, dunes, and washes below 900 m in various plant communities of southwestern North America. It is reported to be a dioecious plant (Webster, 1993), although it appears to be in a diclinous condition other than dioecy proper due to the presence of monoecious morphs in several *C. californicus* populations of southern California (Martin, 1995). The range of *C. californicus* extends from the central and south coast of the California Floristic Province to the Desert Province of California, Arizona, and Baja California (Webster, 1993). Although *C. californicus* can be found in various desert communities of the southwest, it is a prominent component in several associations of coastal sage scrub throughout southern California (Howell, 1929; Kirkpatrick and Hutchinson, 1977; Westman et al., 1981; Zembal and Kramer, 1984; Wheeler, 1988; Martin, 1995).

Kirkpatrick and Hutchinson (1977) described *C. californicus* as a co-dominant of the

Lepidospartum squamatum - Eriodictyon crassifolium - Yucca whipplei association (association 2) in Riversidian coastal sage scrub. This association is confined to washes and gently sloping fans between 300 and 450 m above sea level in the basin bound by the Santa Ana, San Gabriel, San Bernardino, and San Jacinto Mountains (Kirkpatrick and Hutchinson, 1977, 1980). The dominance of the tallest stratum is highly variable, but usually consists of rounded evergreen shrubs more than two meters tall (i.e. *Rhus ovata* S. Watson, *Rhus integrifolia* (Nutt.) Brewer & S. Watson, *Malosma laurina* (Nutt.) Abrams, and *Juniperus californica*), while a variable proportion of the space between the tall shrubs is dominated by smaller shrubs (i.e. *Lepidospartum squamatum* (A. Gray) A. Gray, *Eriodictyon crassifolium* Benth., *Eriodictyon trichocalyx, Yucca whipplei, Eriogonum fasciculatum, Artemisia californica* Less., and *C. californicus*). *Croton californicus* had a 60% frequency in this association (Kirkpatrick and Hutchinson, 1977). Westman et al. (1981) reported *C. californicus* to be associated with *Encelia farinosa* Torrey & A. Gray, *Mirabilis californica, A. californica, E. fasciculatum, Opuntia parryi, Dudleya lanceolata, Keckiella antirrhinoides* (Benth.) Straw, *Malacothamnus fasciculatus* (Torrey & A. Gray) E. Greene, *Solanum parishii* A. A. Heller, and *Yucca schidigera* K. E. Ortgies in postburn Riversidian coastal sage scrub just south of Redlands, California. This was an *Encelia farinosa - Mirabilis californica* association (association 3), however, Kirkpatrick and Hutchinson (1977) did not find *C. californicus* in this association.

Several authors have listed *C. californicus* as a dominant species in the Santa Ana River floodplain of Orange, Riverside, and San Bernardino Counties (Howell, 1929; Zembal and Kramer, 1984; Wheeler, 1988; Martin, 1995). Zembal and Kramer (1984) and Wheeler (1988) concluded that *C. californicus* has habitat requirements similar to the endangered *Eriastrum densifolium* ssp. *sanctorum* (Milliken) H. Mason as well as *L. squamatum, Eriodictyon trichocalyx, Eriogonum fasciculatum*, and *Ericameria pinifolia* in the Santa Ana River floodplain of San Bernardino County. *Juniperus californica, Y. whipplei, O. parryi, M. californica, E. farinosa, R. ovata, Lotus scoparius, Gutierrezia californica* (DC.) Torrey & A. Gray, *Opuntia littoralis, Senecio flaccidus, Solanum xanti*, and *Rhamnus crocea* were also associated with *C. californicus* in these areas (Zembal and Kramer, 1984; Wheeler, 1988). A similar floodplain association in a Redlands location of the Santa Ana River floodplain was reported by Martin (1995). The above dominants of the Santa Ana River floodplain correlate highly with the species composition of Kirkpatrick and Hutchinson's (1977) Riversidian coastal sage scrub and Thorne's (1976) inland sage scrub. Floodplains and washes are often occupied by coastal sage scrub because actively eroding surfaces give the easily dispersed subligneous shrubs a distinct advantage over both perennial grasses and chaparral shrubs (Kirkpatrick and Hutchinson, 1980).

The ability of coastal sage scrub to regenerate after fire has been reported widely. Previously, coastal sage scrub shrubs were thought to resprout poorly from root crowns after fire (Horton and Kraebel, 1955; Hanes, 1971; Kirkpatrick and Hutchinson, 1980) with most postfire regeneration produced from seedlings (Hanes, 1971). Most studies now indicate that coastal sage scrub shrubs are vigorous sprouters after fire (Wells, 1962; Mooney, 1977; Westman, 1981; Westman et al., 1981; Malanson and O'Leary, 1982; Keeley and Keeley, 1984; Martin, 1984) and that the percentage of topkilled shrubs that resprout varies with fire intensity (Westman, 1981; Westman et al., 1981) and slope aspect (Martin, 1984). It is now known that coastal sage scrub dominants typically produce basal sprouts continually in the absence of fire (Malanson and Westman, 1985).

Coastal sage scrub historically occupied approximately 2.5% of the area in the state of California and only 10-15% of this original area remained in 1981 due to rapid urbanization (Westman, 1981). It is important that we continue to study this endangered ecosystem in order to conserve and manage the small remaining areas that coastal sage scrub now occupies. Little has been published on the ability of *C. californicus* to regenerate following fire. Westman et al. (1981) reported an increase of *C. californicus* in one postburn study site. It is suspected that *C. californicus* is fire-adapted and will respond favorably to fire disturbance in coastal sage scrub. This study reports the response of *C. californicus* and its associated species to wildfire in a coastal sage scrub community of a southern Californian floodplain. This paper also presents the postfire patterns of sex expression in *Croton* to observe how fire affects reproduction in a diclinous species.

Methods

Approximately 16 ha of Riversidian coastal sage scrub association 2 in the Santa Ana River floodplain of East Highlands, California burned as the result of a wildfire in late summer of 1992. This burn area is located immediately south of where Weaver Street intersects Greenspot Road. Postburn measurements of *Croton californicus* were performed on 29 April 1994. Plot sampling, using 25 m^2 quadrats, was performed in the burn and control areas to determine population density, cover, and frequency for all perennial species as well as to record sexual condition for *C. californicus*. Cover was calculated from plant crown diameters and sexual condition was determined by examining all of the flowers on a plant and by the presence or absence of fruits. Monoecious morphs were determined to be plants that bore both pistillate and staminate flowers. Twenty quadrats were randomly sampled in the burn area and twenty quadrats were randomly sampled in approximately 6 ha of an adjacent unburned control area. The control area was a continuation of the flood plain immediately west of the burn area which contained a similar topography and slope aspect.

A second set of postburn measurements were taken on 30 April 1995 in the East Highlands burn. Plot sampling, using 1 m^2 quadrats, was performed to determine presence and frequency of all perennial species as well as density, cover, and sexual condition for *C. californicus*. Cover was calculated from plant crown diameters. Newly germinated seedlings were recorded and noted if occurring in rodent disturbed soils. Two hundred 1 m^2 quadrats were randomly sampled in each of the burn and control areas.

Approximately 3 ha of Riversidian coastal sage scrub association 3 (Kirkpatrick and Hutchinson, 1977) in the Santa Ana River floodplain near the mouth of the Santa Ana Canyon, California burned as the result of a wildfire in late summer of 1994. This burn area is located immediately southwest of where Santa Ana Canyon Road intersects Greenspot Road. This association was dominated by resprouting *Encelia farinosa* and *Mirabilis californica*. Postburn measurements and observations were performed on 19 May 1995 to document *C. californicus* resprouting from basal root crowns during the first postfire season.

Chi-square contingency analysis was used to compare the differences between the burn and control densities for *C. californicus* and the other dominant perennials. Community coefficients of similarity, percent similarity indices, and dominance and diversity indices were calculated for comparisons between the burn and control areas (Brower and Zar, 1984). Comparisons were made between sexual morphs and crown diameters for *C. californicus* in the burn and control areas using one-way ANOVA.

Results

Reproduction of *Lotus scoparius* and *Croton californicus* was greatly stimulated by the fire indicated by a significant increase ($p < 0.001$) in density in the burn area at 1.5 years postburn (Table 1). These two species were the number one and two dominant postburn species with importance values (*IV*) of 145.3% and 96.1% respectively. Preburn dominants *Eriodictyon trichocalyx* (*IV* = 85.1%), *Eriogonum fasciculatum* (*IV* = 81.8%), *Senecio flaccidus* (*IV* = 22.3%), and *Opuntia littoralis* (*IV* = 22.1%) were significantly reduced ($p < 0.001$) in density after fire. Total density for all species was higher in the burn area, while total cover and frequency were lower when compared to the control area at 1.5 years postburn. Total frequency for all species in the burn area was higher than the control area at 2.5 years postburn (Table 2). *Eriodictyon trichocalyx*, *Senecio flaccidus*, *Artemisia dracunculus*, and *Rhamnus crocea* were not encountered at 1.5 years postburn but were observed at 2.5 years postburn indicating some postfire recovery. Unique species to the burn area were *Mirabilis californica* and *Solanum xanti* while unique species to the control area were *Ericameria pinifolia* and *Lupinus albifrons*.

Coefficients of community similarity and percent similarity were relatively low at 1.5 years postburn (Table 3). These coefficients increased considerably by 2.5 years postburn. Species dominance was higher in the burn area with a Simpson's index of dominance of 0.43 and 0.28 for the burn and control areas respectively at 1.5 years postburn. Species diversity was higher in the control area with a Shannon diversity index of 0.44 and 0.80 for the burn and control areas respectively at 1.5 years postburn. Species diversity could not be calculated with the 2.5 years postburn data, however, species richness for the burn area indicated that these values should have been higher at 2.5 years postburn. There were 8 species measured in the burn area out of 16 possible species at 1.5 years postburn (Table 1), while 14 species were encountered in the burn area out of 16 possible species at 2.5 years postburn (Table 2).

Importance values for *C. californicus* increased in the burn area three fold when compared to the control area at 1.5 years postburn (Table 4). *Croton* significantly increased ($p < 0.001$) in density and cover approximately three times and eight times that of the control at 1.5 years and 2.5 years postburn respectively. There was an increase from 3200 to 6350 individuals/ha and 3.4 to 6.9% cover in the burn area during the third postburn year. Mean crown diameter for the burn area was slightly smaller than control area at 1.5 years postburn and was larger than the control area at 2.5 years postburn (Table 4). The large size of postfire plants and the insignificant difference between burn and control crown diameters at 1.5 years postburn indicates that a considerable number of these plants could not have originated from seed and must have resprouted. Resprouting was observed in the Santa Ana Canyon burn at 0.5 years postburn with a postfire sprouting rate of 68.8% ($n = 11$ resprouts out of 16 topkilled plants) and a mean crown diameter of 69.5±15.2 cm. Most of the resprouts exhibited large charred basal stems.

If 100% of the East Highlands preburn plants resprouted following fire, then approximately 66% of 1.5 years postburn density was derived from first and second season seedlings, while approximately 50% of the 2.5 years postburn density was produced from second and third season seedlings. A higher proportion of small plants was observed in the burn area when compared to

Table 1. Dominance of *Croton californicus* and associated perennials in burn and control areas of coastal sage scrub in East Highlands, California at 1.5 years postburn. Ad = *Artemisia dracunculus*; Cc = *Croton californicus*; Dl = *Dudleya lanceolata*; Ep = *Ericameria pinifolia*; Et = *Eriodictyon trichocalyx*; Ef = *Eriogonum fasciculatum*; Jc = *Juniperus californica*; Ls = *Lotus scoparius*; La = *Lupinus albifrons*; Mc = *Mirabilis californica*; Ol = *Opuntia littoralis*; Op = *O. parryi*; Rc = *Rhamnus crocea*; Sf = *Senecio flaccidus*; Yw = *Yucca whipplei*. *** = $p < 0.001$.

	Dominance													
	Density (no./ha)		Relative density (%)		Cover (%)		Relative cover (%)		Frequency (%)		Relative frequency (%)		Importance value (%)	
Species	Burn	Control	Burn	Control	Burn	Control	Burn	Control	Burn	Control	Burn	Control	Burn	Control
Ad	0	80	—	1.4	—	1.0	—	5.5	—	15.0	—	4.7	—	11.6
Cc	*** 3200	*** 960	46.4	17.3	3.4	1.2	24.7	6.8	55.0	25.0	25.0	7.8	96.1	31.9
Dl	0	60	—	1.1	—	<0.1	—	0.1	—	15.0	—	4.7	—	5.9
Ep	0	60	—	1.1	—	0.8	—	4.5	—	10.0	—	3.1	—	8.7
Et	*** 0	*** 2560	—	46.0	—	3.7	—	20.3	—	60.0	—	18.8	—	85.1
Ef	*** 300	*** 980	4.4	17.6	0.2	7.1	1.2	39.2	40.0	80.0	18.2	25.0	23.8	81.8
Jc	20	20	0.3	0.4	<0.1	1.0	0.2	5.5	5.0	5.0	2.3	1.6	2.8	7.5
Ls	*** 3180	*** 20	46.1	0.4	8.6	<0.1	62.8	0.2	80.0	5.0	36.4	1.6	145.3	2.2
La	0	20	—	0.4	—	0.7	—	3.6	—	5.0	—	1.6	—	5.6
Mc	40	0	0.6	—	<0.1	—	0.2	—	10.0	—	4.6	—	5.4	—
Ol	*** 100	*** 300	1.5	5.4	0.1	0.9	0.8	4.8	20.0	35.0	9.1	10.9	11.4	21.1
Op	20	60	0.3	1.1	0.4	0.1	3.1	0.5	5.0	15.0	2.3	4.7	5.7	6.3
Rc	0	20	—	0.4	—	0.2	—	0.8	—	5.0	—	1.6	—	2.8
Sf	*** 0	*** 300	—	5.4	—	1.4	—	7.5	—	30.0	—	9.4	—	22.3
Yw	40	120	0.6	2.2	1.0	0.2	6.9	0.8	5.0	15.0	2.3	4.7	9.8	7.7
Total =	6900	5560	100	100	13.7	18.2	100	100	220.0	320.0	100	100	300	300

Table 2. Frequency (%) and relative frequency (%) of *Croton californicus* and associated perennials in burn and control areas of coastal sage scrub in East Highlands, California at 2.5 years postburn. Two hundred 1m^2 quadrats were measured in the burn and control areas each. * = species found only in the control area. ** = species new to burn area (not encountered at 1.5 year postburn). *** = species found only in the burn area.

	Frequency (%)		Relative frequency (%)	
Species	Burn	Control	Burn	Control
Artemisia dracunculus L. **	0.5	0.5	0.7	0.8
Croton californicus Muell. Arg.	33.0	5.5	43.4	8.6
Dudleya lanceolata (Nutt) Britton & Rose **	1.0	1.5	1.3	2.3
Ericameria pinifolia (A. Gray) H. M. Hall *	-----	1.0	-----	1.6
Eriodictyon trichocalyx A. A. Heller **	2.5	25.0	3.3	39.1
Eriogonum fasciculatum Benth.	7.5	23.0	9.9	35.9
Juniperus californicus Carriere	0.5	0.5	0.7	0.8
Lotus scoparius (Nutt.) Ottley	25.0	0.5	32.9	0.8
Lupinus albifrons Benth. *	-----	1.0	-----	1.6
Mirabilis californica A. Gray ***	0.5	-----	0.7	-----
Opuntia littoralis (Engelm.) Cockerell	1.5	2.0	2.0	3.1
O. parryi Engelm.	1.5	1.5	2.0	2.3
Rhamnus crocea Nutt. **	0.5	0.5	0.7	0.8
Senecio flaccidus Less. **	0.5	1.0	0.7	1.6
Solanum xanti A. Gray ***	1.0	-----	1.3	-----
Yucca whipplei Torrey	0.5	0.5	0.7	0.8
Total =	76.0	64.0	100	100

Table 3. Coefficients of community similarity for perennials in burn and control areas of coastal sage scrub in East Highlands, Calfornia. Jaccard's coefficient (CC_j), Sorensen's coefficient (CC_s) were analyzed using species presence. Percent similarity was analyzed using relative density (PS_d) and relative cover (PS_c). A coefficient of appoximately 70% is considered an indication that the two communities (areas) are virtually identical (Whittaker, 1975).

	Coefficient of community similarity			
Postburn time	CC_j (%)	CC_s (%)	PS_d (%)	PS_c (%)
1.5 years	46.7	63.6	8.9	10.5
2.5 years	75.0	85.7	-----	-----

the control area (Figure 1). If second year seedlings were considered to be < 12 cm in diameter (a conservative maximum size) at 1.5 years postburn, there were significantly more ($p < 0.001$) seedlings in the burn area versus the control area. There was significantly more ($p < 0.001$) new seedlings germinating in the burn area when compared to the control area during the third postburn season, with 57% of the burn seedlings occurring in rodent disturbed soils. When third season seedlings are entered in the calculations, mean crown diameter for the burn and control areas at 2.5 years postburn were 30.1±22.1 and 32.2±21.9 cm respectively. The recruitment of small seedlings to the burn area decreases the mean crown diameter when compared to 1.5 years postburn mean crown diameter (31.8±18.5 cm) even though cover has increased.

Postburn *C. californicus* population patterns of sex expression were not greatly affected by the fire. Monoecious morphs of *Croton* were observed in both the burn and control areas (Table 5). Relative abundance of monoecious morphs was low with a total relative abundance of 1.0% and values for the burn and control being 0.8% and 1.8% respectively. Females were more numerous than males in both the burn and control areas. Male:female sex ratios were 0.92 for the burn and 0.80 for the control with a total male:female ratio of 0.90. Female biased sex ratios were slightly less pronounced in the burn area especially at 1.5 years postburn.

Male plants of *C. californicus* were larger than female plants (Table 6). Male crown diameter was significantly larger ($p < 0.05$ or $p < 0.001$) in both burn and control areas regardless of

Table 4. Dominance and crown diameters (mean ± SD) of *Croton californicus* in burn and control areas of coastal sage scrub in East Highlands, California. *IV* = importance value. K = number of 25 m^2 quadrats measured at 1.5 years postburn and 1 m^2 quadrats measured at 2.5 years postburn. *** = $p < 0.001$ between burn and control areas. Crown diameters at 2.5 years postburn were calculated without third season seedlings.

			Dominance							
Postburn time	Area	K	Density (no./ha)	Relative density (%)	Cover (%)	Relative cover (%)	Frequency (%)	Relative frequency (%)	*IV* (%)	Crown diameter (cm)
1.5 years	Burn	20	*** 3200	46.4	3.4	24.7	55.0	25.0	96.1	31.8±18.5
	Control	20	*** 960	17.3	1.2	6.8	25.0	7.8	31.9	34.9±21.0
2.5 years	Burn	200	*** 6350	-----	6.9	-----	33.0	43.4	-----	37.8±18.8
	Control	200	*** 750	-----	0.9	-----	5.5	8.6	-----	34.1±21.3

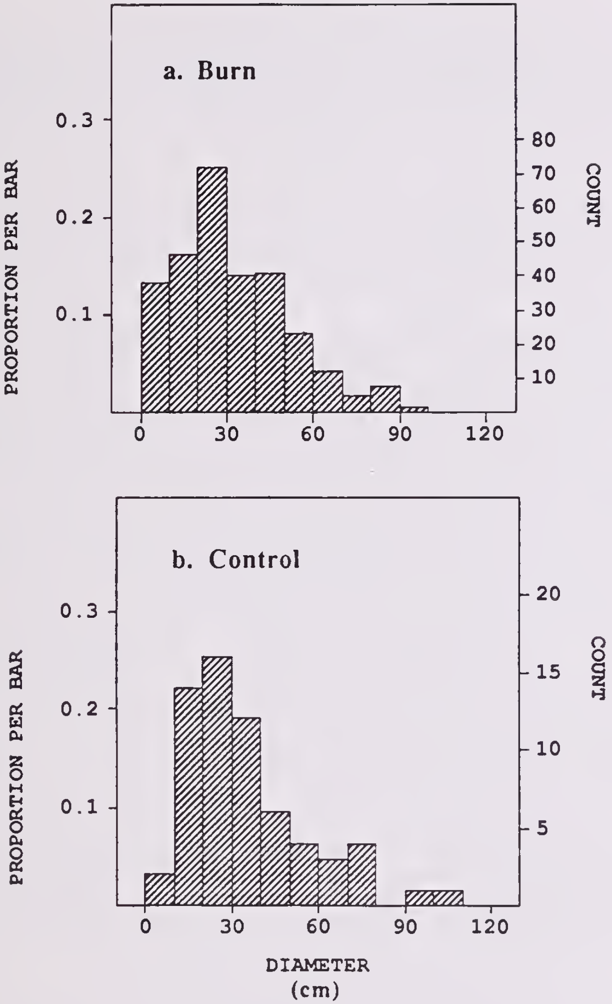

Figure 1. Proportion of *Croton californicus* by size class for burn (a.) and control (b.) areas in East Highlands, California at 1.5 years and 2.5 years postburn. Diameter is in cm. Proportion of 1.0 = 100%. Count = number of individuals.

Table 5. Relative abundance (%) for sexual morphs of *Croton californicus* in burn and control areas of coastal sage scrub of East Highlands, California. K = number of $25m^2$ quadrats measured at 1.5 years postburn or $1m^2$ quadrats measured at 2.5 years postburn.

		Relative abundance						
Postburn		Female		Male		Monoecious		Male:Female
time	Area	n	%	n	%	n	%	ratio
1.5 years	Burn (K=20)	76	51.0	72	48.3	1	0.7	0.95
	Control (K=20)	23	54.8	18	42.9	1	2.4	0.78
2.5 years	Burn (K=200)	50	52.6	44	46.3	1	1.1	0.88
	Control (K=200)	7	53.8	6	46.2	0	0.0	0.86
	Total =	156	52.2	140	46.8	3	1.0	0.90

postburn time. Both male and female crown diameters increased considerably in the burn area from 1.5 years to 2.5 years postburn, exceeding the mean crown diameters of the control area by 2.5 years postburn. Monoecious morphs, nonflowering plants, and seedlings were also found to be significantly different ($p < 0.001$) for crown diameters, however, sample sizes were very small.

Discussion

Croton californicus is a dominant species in Riversidian coastal sage scrub and is associated with a wide array of perennials reported by Howell (1929), Kirkpatrick and Hutchinson (1977), Westman et al. (1981), Zembal and Kramer (1984), and Wheeler (1988). The association 2, observed in this study, is considered to have structural complexity and species diversity unrivalled among the rest of the coastal sage scrub associations (Kirkpatrick and Hutchinson, 1977). Many of the dominants of this community appear to recover quickly from or to even be stimulated by fire. This is observed by the appearance of preburn dominants *E. trichocalyx*, *S. flaccidus*, *A. dracunculus*, *D. lanceolata*, and *R. crocea* in the burn area within 2.5 years. *Eriodictyon trichocalyx* is known to recolonize postburn sites via seedlings (Hanes and Jones, 1967) as well as resprouts from a rhizomatous root system (Hanes, 1971). *Eriogonum fasciculatum* appears to be recovering, but not as rapidly as other species. It is known to increase in postburn sites (Hanes and Jones, 1967), but is a weak resprouter and initially exhibits decreased reproduction (Westman et al., 1981).

Mirabiliscalifornica and *S. xanti* were unique species to the burn area and indicated that fire stimulated growth of these pioneer perennials. Westman et al. (1981) reported *M. californica* to resprout after fire and postburn cover increased two fold within 3 years. Other current study species that are known to resprout after fire include *O. littoralis*, *O. parryi*, *R. crocea*, and *Y. whipplei* (Westman et al., 1981).

Species stimulated by fire exhibited increased densities and rapid growth in cover from resprouting plants and/or seed germination. *Lotus scoparius* displays vigorous growth, becoming the dominant species within 1.5 years postburn. This subshrub is an excellent colonizer of disturbed areas (Steppan, 1991; Nilsen and Muller, 1981) and is well known for its ability to dominate areas early after fire (Went et al., 1952; Hanes, 1971; Kirkpatrick and Hutchinson, 1977; Westman, 1981; Westman et al., 1981; Westman and O'Leary, 1986). It has not been observed to resprout after fire (Hanes, 1971; Keeley and Keeley, 1984) and its seeds require heat scarification for germination (Went et al., 1952; Christensen and Muller, 1975; Nilsen and Muller, 1981; Keeley, 1991). *Lotus scoparius* populations are even-aged because 100% of seed germination occurs within the first 2 years following fire (Nilsen and Muller, 1981).

Lotusscoparius reaches flowering size by the second postfire season (Horton and Kraebel, 1955) producing maximum cover 2-4 years postfire (Westman, 1981; Westman and O'Leary, 1986) with approximately an 80% decrease in cover by 7 years (Westman, 1981) and a 95% decrease in cover 9-21 years postfire (Hanes, 1971). Keeley and Keeley (1984) reported at the end of the second postfire season *L. scoparius* seedlings were substantially larger than most other species with an average cover of 466 cm^2. Cover values from the current study were more than five times higher at 1.5 years postburn with average values of 2709 cm^2. Westman et al. (1981) reported considerable increases in cover of *L. scoparius* at two burn sites at 2-3 years postburn. One of these sites had cover values of 7.2% at about 2.5 years postburn, very close to the 8.6% cover at 1.5 years postburn reported in this study.

The second most vigorous colonizer of the postburn area of this study was *C. californicus*. It appears that *Croton* was tremendously stimulated by fire and postburn sites for at least 3 years. Postfire reproduction includes resprouting and seed germination with considerable numbers of resprouts and seedlings produced. Unfortunately, the exact proportion of each type of propagation could not be quantified because the author was not present at East Highlands at 0.5 years postburn to observe it. Since a high resprouting rate was observed at Santa Ana Canyon, it is possible that resprouting could be higher than 68% if fire intensity is lower (Westman et al., 1981). If 100% of the East Highlands *Croton* resprouted, there still would be a tremendous amount of seedlings produced the first, second, and third seasons postfire. Many coastal sage scrub dominants exhibit decreased seedling establishment the first postfire season with the appearance of numerous seedlings the second season from seeds produced by resprouts (Westman et al., 1981; Malanson and O'Leary, 1982; Keeley and Keeley, 1984).

Table 6. Crown diameters (mean ± SD) for sexual morphs *Croton californicus* in burn and control areas of coastal sage scrub of East Highlands, California. All units are in cm. Sample sizes are numbers in parentheses (n). K = number of $25m^2$ quadrats measured at 1.5 years postburn or $1m^2$ quadrats measured at 2.5 years postburn. * = $p < 0.05$ between morphs. *** = $p < 0.001$ between morphs.

			Crown diameter				
Postburn time	Area	K	Female	Male	Monoecious	Nonflowering	Seedling
1.5 years	Burn	20	31.2±17.6*** (76)	35.2±18.6*** (72)	60.0*** (1)	11.0±5.0*** (11)	----- -----
	Control	20	34.1±17.8* (23)	41.2±23.9* (18)	60.0* (1)	14.8±4.9* (6)	----- -----
2.5 years	Burn	200	35.7±16.2*** (50)	41.0±19.1*** (44)	96.0*** (1)	15.0±2.2*** (4)	2.8±1.2*** (28)
	Control	200	32.9±19.2 (7)	39.7±24.1 (6)	----- -----	10.0 (1)	5.0 (1)
		Total =	33.1±17.2*** (156)	38.0±19.7*** (140)	72.0±20.8*** (3)	12.7±4.7*** (22)	2.8±1.2*** (29)

Although it appears that fire initially stimulates seed germination of *Croton*, seeds continue to germinate up to the third postburn season. Emery (1995) states that *C. californicus* does not require any special treatments for germination. The author of the current study has made numerous attempts and treatments to facilitate seed germination in the lab and has observed 0% germination. It appears that *C. californicus* has very complex seed germination requirements. Scarification appears to be one component of these requirements. It may be possible that rodents consume the seed and chemically scarify the seed coat. Over 57% of the third postburn season seedlings occurred in rodent disturbed areas Seedlings (n = 28) had a frequency of 7.5% with as many as 7 seedlings in one 1 m^2 quadrat. Seedling aggregation in rodent disturbed areas may be due to rodent activity and/or scarification. Pocket gophers become common in postburn chaparral within the second season after fire (Christensen and Muller, 1975) and coastal sage scrub exhibits higher rodent density, diversity, and activity when compared to chaparral (Bradbury, 1978). Rodent activity might explain why germination in the burn area continued to be higher than the more woody, chaparral-like control area during the second and third postburn seasons.

Density and cover values of *C. californicus* in this study were similar to those found by Zembal and Kramer (1984) and Martin (1995). The high density (6350 plants/ha) and cover (6.9%) in the burn area at 2.5 years postburn of the current study are close to the density (6550 plants/ha) and cover (5.48%) in an undisturbed San Bernardino population reported by Martin (1995). This demonstrates that fire stimulates growth and reproduction of *Croton* to optimal densities and cover within 2-3 years after fire.

Croton californicus and *L. scoparius* share many morphological characteristics and ecological strategies in common. First, both species are subshrubs (Hellmers et al., 1955; Webster, 1993). Second, both species were significantly stimulated by fire and dominated the postburn areas of this study. Third, it appears that both species have seeds that require scarification with fire being one mode of scarification (Went et al., 1952; Christensen and Muller, 1975; Nilsen and Muller, 1981). Fourth, unlike the fibrous roots that most coastal sage scrub subshrubs have (Hellmers et al., 1955), both species have clearly defined taproots. Hellmers et al. (1955) reports that *L. scoparius* has a clearly defined taproot. *Croton californicus* also has a clearly defined taproot with mature plants possessing taproots greater than 1 m deep (Martin, field observations). Fifth, both species are drought-deciduous (Nilsen and Muller, 1981; Martin, field observations). Sixth, both species exhibit continual basal sprouting in the absence of fire (Malanson and Westman, 1985; Webster, 1993). These features appear to allow both subshrubs to rapidly colonize and dominate disturbed areas of xeric, fire-adapted ecosystems.

Croton californicus and *L. scoparius* differ from each other in two ways. First, *Croton* resprouts following fire while *Lotus* does not. Second, seed germination of *C. californicus* is stimulated for at least 3 years postfire while 100% of seed germination for *L. scoparius* occurs within the first 2 years postfire. Both species are pioneer plants in succession and in many situations will eventually be displaced by more woody shrub species. The increased sprouting vigor and continual seed germination may allow *C. californicus* to persist longer in the succession of coastal sage scrub communities. Most perennial coastal sage scrub species continually sprout and produce non-dormant, non-fire resistant seeds that are constantly recruited between fires (Malanson and O'Leary, 1982). *Croton* differs from this in that its seeds appear to be somewhat dormant and fire-resistant. The hardseededness and relatively large size of *C. californicus* seeds probably reflect some fire-adaptations that differ from the typical light, non-fire resistant seeds produced by most coastal sage scrub perennials (Kirkpatrick and Hutchinson, 1980; Malanson and O'Leary, 1982).

Postburn *C. californicus* population patterns of sex expression were not greatly affected by the fire and very similar to those reported by Martin (1995). Again, size appears to be a secondary sex character in which males are larger than females. Most secondary sex characters of plants are subtle and usually are expressed in terms of growth, resource allocation, and timing or longevity (Richards, 1986). Female biased sex ratios, as observed in this study, are rarer in nature than male biased sex ratios (Willson, 1983; Richards, 1986). The sex ratio in plant populations may not be equal due to microhabitat segregation by the different sexes (Handel, 1983). There is some evidence in subdioecious species that females are relatively constant in their sex expression and it is the polleniferous plants which are variable (Heslop-Harrison, 1957; Charlesworth and Charlesworth, 1978). This may be true with *C. californicus* because when male and monoecious plants are added together, the male:female ratio is closer to 1.00.

The frequency of monoecious morphs observed in this study was low as has been previously observed (Martin, 1995). Although monoecious individuals compose only a small fraction of a given population, their presence suggests that *C. californicus* may have an unusual breeding system. The author will be publishing results of a flowering phenology study that monitored individual plants for the 1994 season by quantifying the number of pistillate and/or staminate flowers through time to reveal the constancy for sex expression of each individual plant. These plants are to be observed for two more seasons to discover if *Croton* is genetically and/or environmentally subdioecious or if sex reversal is occurring.

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FLORISTIC RELATIONSHIPS OF THE EASTERN MOJAVE DESERT: A QUANTITATIVE ANALYSIS OF LOCAL FLORAS

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Abstract

Local floras sample the regional flora at the landscape scale. Quantitative analyses of the presence/absence of species recorded in a sample of local floras can objectively define the most important floristic elements and floristic areas from within a region. Principal components analysis (PCA) of similarities among local floras produces results that can be directly mapped for explicit geographic interpretation. This technique is applied here to an analysis of the floristic relationships between the eastern Mojave Desert region of California and adjacent regions.

Botanists have traditionally divided the desert region of California into three floristic areas: the Colorado Desert of Riverside, Imperial, and San Diego counties; the Mojave Desert of Kern and San Bernadino counties, and the Northern Mojave Desert or "Inyo Region" of Inyo County. A PCA analysis of a database of 112 local floras from the western USA suggests that all of the desert areas of southeastern California, southern Nevada, and southwestern Arizona belong in a single major floristic area--the Sonoran Floristic Province. Four subdivisions of the Sonoran Floristic Province in the western USA can be distinguished, only two of which occur in California--a broadly defined Northern Mojave Desert District and a "California Desert District" which includes all of the Colorado Desert and much of the Mojave Desert, as the latter is traditionally defined. The "eastern Mojave Desert area" of California is placed in the Northern Mojave Desert District.

Introduction

Floristic plant geography is concerned with the delineation of floristic areas and floristic elements (McLaughlin, 1994). Floristic areas are geographic units of any size that possess a characteristic and distinct flora (Takhtajan, 1986). Phytogeographers typically treat floristic areas as a nested hierarchy of geographic units (Takhtajan, 1986; McLaughlin, 1992a); e.g., floristic districts nested within floristic provinces, which are nested within floristic regions, which are in turn nested within floristic kingdoms. Floristic elements are groups of species with more or less coincident ranges. Botanists commonly make use of the concept of floristic elements, often without explicitly naming them as such; e.g. the "areal types" of Whittaker and Niering (1964), the "geographic range" types of Thorne et al. (1981), and the "floristic centers of distribution" of Morefield et al. (1988) are all essentially floristic elements.

Most systems of floristic elements are strictly *ad hoc*, devised by authors of local floras by sorting ranges into classes based on descriptions given in regional manuals or monographic treatments. Cain (1947) argued that such *ad hoc* treatments may be useful but that there is little point to trying to develop a "universal" system of floristic elements and floristic areas because each species has its own unique range based on its ecological tolerances and evolutionary history. This is an uncritical extrapolation of patterns and processes from community scales to regional or continental biogeographic scales. McLaughlin (1986, 1989, 1992a) and others (see references in McLaughlin, 1994) have demonstrated, for example, that floristic areas at larger geographic scales can be objectively and repeatably defined using quantitative methods.

The objective of this paper is to examine the floristic relationships of the area known as the "eastern Mojave Desert" of California in northeastern San Bernadino County, using the procedures of McLaughlin (1992a, 1994). The flora of this region has been studied in detail by Thorne et al. (1981). The purpose of this study is to investigate the eastern Mojave Desert region of California in a broader, regional floristic context.

Botanists traditionally have subdivided the desert region of southeastern California into the Mojave Desert in the north and the Colorado Desert in the south (Parish 1930, Munz 1935). Shreve (1925) thought at first that the two deserts were part of the same botanical region, but later he excluded the Mojave Desert from his definition of the Sonoran Desert (Shreve, 1942), which included the desert regions of southeastern California, southwestern Arizona, northwestern Sonora, and Baja California. Stebbins and Major (1965) found it useful to distinguish the "Inyo Region", roughly that portion of Inyo County east of the Sierra Nevada, from the rest of the Mojave Desert. The "Northern Mojave Desert" of DeDecker (1984) is essentially the same as the "Inyo Region" of Stebbins and Major (1965). Thus three subdivisions of the California deserts are generally recognized: (1) the Colorado Desert, as a part of the Sonoran Desert, located in eastern San Diego County, Imperial County, and eastern Riverside County (Shreve, 1942); the Mojave Desert, located mostly in eastern Kern County and most of San Bernadino County; and (3) the northern Mojave Desert, located mostly in Inyo County. An objective of this study is to examine whether this traditional framework accurately reflects the distributions of plants within this region.

Methods

The methods used here have been developed over several studies (McLaughlin 1986, 1989, 1992a) and discussed in detail elsewhere (McLaughlin, 1994). The key feature is the use of local floras as landscape-scale samples of the regional flora. A data base is first assembled from available local floras; similarity indices are calculated for each pair of floras in the data base; the similarity matrix is then analyzed using principal components analysis (PCA) with varimax rotation; and the results are then plotted on maps. The data base can be subdivided by range size to delimit floristic areas at different geographic scales (McLaughlin, 1992a), and species can be sorted into floristic elements indirectly by calculating the product of the matrix of rotated loadings and the raw data matrix (McLaughlin, 1994).

For this study the data base of McLaughlin (1992a) was expanded and updated in several ways. First, there have been many changes in the taxonomy and nomenclature of plants in the flora of the western USA since the data base was first assembled. Nomenclature was updated using Hickman (1993) and Kartesz (1994). Where these references differ in their treatments, Hickman (1993) was followed for taxa found primarily in California. For taxa with wider distributions, the treatments in Kartesz (1994) were followed. Second, several floras used in

TABLE 1. Updates of local floras incorporated into the current data base. Flora numbers refer to the numbers shown in Fig. 1.

Flora No.	Flora	Reference
F2	Organ Pipe Cactus National Monument	Pinkava et al. (1992)
F22	Joshua Tree National Monument	Unpublished Checklist obtained from Joshua Tree National Park
F24	White Mountains, California-Nevada	Morefield et al. (1988)
F30	Bryce Canyon National Park	Spence and Buchanan (1993)
F31	Capital Reef National Park	Heil et al. (1993)
F73	Lassen Volcanic National Park	Gillet et al. (1995)
F90	Santa Monica Mountains	Raven et al. (1986)

previous analyses have been updated (Table 1) and these updates were incorporated into the data base. Third, several new floras were substituted for floras previously in the data base (Table 2). In most cases, the newly incorporated flora is more inclusive than the flora it replaces, or it provides for a better distribution of floras within the study region. Fourth, eight additional floras have been added to the data base (Table 3). In all cases these new floras fill gaps in the data base. Finally, in order to better focus on floristic relationships within the southwestern deserts, three floras from this region have been added for the current study (Table 3). The distribution of local floras now in the data base is shown in Fig. 1; the numbering of floras in this figure differs from that used in previous publications.

The database was edited using Quattro Pro® for Windows; PCAs were done using Systat®6.0; and contour maps were prepared using Surfer®6.0. Similarities were calculated as Jaccard's Index:

$$S(J)=\frac{C}{(A+B-C)}$$

where S(J) = Jaccard's Index, C = the number of species in common between two local floras, A = the size of the smaller local flora, and B = the size of the larger local flora. In previous studies I have used Simpson's Index (C/A), which I prefer for comparison of local floras, particularly since the sizes of the floras in the data base differ considerably. Jaccard's Index was used here because of limitations of time: Systat®6.0 can calculate Jaccard's Index from a matrix of presence/absence data, but it does not include an algorithm for Simpson's Index. I subdivided the data base for this study into just 2 parts--one for more narrowly distributed species and one for the more widely distributed species.

TABLE 2. Substitutions of local floras incorporated into the current data base. Flora numbers refer to numbers shown in Fig. 1.

Flora No.	Previous Local Flora	Current Local Flora	Reference to Current Local Flora
F9	Hualapai Planning Unit	Northern Hualapai Mtns.	Butterwick et al. (1991)
F13	Mule Mountains	Huachuca Mountains	Bowers and McLaughlin (1996)
F16	Carlsbad-Guadalupe area	Guadalupe Mountains	Burgess and Northington (no date)
F23	Aravaipa Canyon	Pinaleno Mountains	McLaughlin (1993)
F52	Yellowstone Nat. Park	Headwaters Yellowstone River	Snow (1992-1994)
F56	Rocky Mountain Nat. Park	Boulder Mountain Park	Hogan (1993)
F86	Pinnacles National Mon.	Hastings Natural History Reservation	Griffin (1972)
F95	Owyhee River Canyon	Steens Mountain	Urban (1981)

Results and Discussion

The data base currently consists of 9158 species known to me to be native to the western United States. Their frequency distribution is shown in Fig. 2. Of these 9158 species, 2030 are not recorded in any of the 109 floras that currently constitute the "permanent" data base. The most widespread species is *Mimulus guttatus*, which is recorded in 91 of the local floras.

The average areal extent of the 109 local floras is 440 km^2 and the average elevational relief is 1314 m. These floras thus, on average, represent areas that constitute large samples of the regional landscape and cover a broad range of possible habitats. Nevertheless, about 41% of the total flora (3766 species) are recorded from either 0 or 1 local flora. That is, within the western USA a substantial proportion of the species are either rare or very localized in their distributions at the regional scale. The average range size for all 9158 species is 6.0 local floras. "Incidence" is defined as the range size (number of local floras) multiplied by the number of species with that particular range size. The area under the incidence curve (Fig. 3) is thus equal to the total number of recorded occurrences of species in the data base. The point which divides this area into to approximately equal halves occurs at 15 local floras. Species recorded from a single flora were not used to calculate similarities between floras. Species recorded in 2 to 15 local floras are treated as "narrow species" in the current study; their average range size is 5.9 local floras. Species recorded in 16 or more local floras are treated as "widespread species;" their average range size is 27.2 local floras.

Two PCAs were done, one with the widespread species and one with the narrow species.

TABLE 3. Local floras added to the data base. Floras F102-F109 are permanent additions, Floras D1-D3 are temporary additions for the current study. Flora numbers refer to numbers shown in Fig. 1.

Flora No.	Flora	Reference
F102	Nevada Test Site	Beatley (1976)
F103	Muddy Mountains	Swearingen (1981)
F104	Kofa National Wildlife Refuge	Russo (1987)
F105	Buenos Aires National Wildlife Refuge	McLaughlin (1992b)
F106	Cooke's Range	Columbus (1988)
F107	House Range	Kass (1988)
F108	Upper Walker River	Lavin (1983)
F109	Peavine Mountain	Williams et al. (1992)
D1	Tucson Mountains	Rondeau (1991)
D2	Clark Mountains	Thorne et al. (1981)
D3	Black Mountains, Death Valley Nat. Mon.	Schram (1982)

The three supplemental floras from the desert region (D1-D3, Table 3) were included only in the PCA for the narrow species. These two PCAs distinguish floristic elements at two spatial scales--widespread species distinguish elements at the scale of floristic provinces and narrow species distinguish elements at the scale of floristic districts within provinces (McLaughlin, 1992a). The first 5 components from the PCA of the widespread species correspond very closely to those of McLaughlin (1992a) and are associated with the five floristic provinces found in the western USA--Cordilleran, Intermountain, Madrean, Californian, and Sonoran. The rotated loadings for the components identified with the Sonoran, California, and Intermountain floristic province are mapped in Figs. 4, 5, and 6, respectively.

All of the floras from the desert areas of southwestern Arizona, southwestern Utah, southern Nevada, and southeastern California fall within the 0.40 isoline for the Sonoran Floristic Element (Fig. 4). I interpret this result as demonstrating that all these desert floras belong to a single floristic province. The California Floristic Element appears to form an important component only in the floras at the western edges of the deserts in California (Fig. 5). The Intermountain Floristic Element extends down to the Spring Range flora (F28) as the dominant element (Fig. 6) north of the desert region. The loading for the Nevada Test Station flora (F102) on the Sonoran element (0.497) is only somewhat higher than its loading on the Intermountain element (0.436), consistent with Beatley's (1976) conclusion that the Nevada Test Site lies at the transition between desert and intermountain floras.

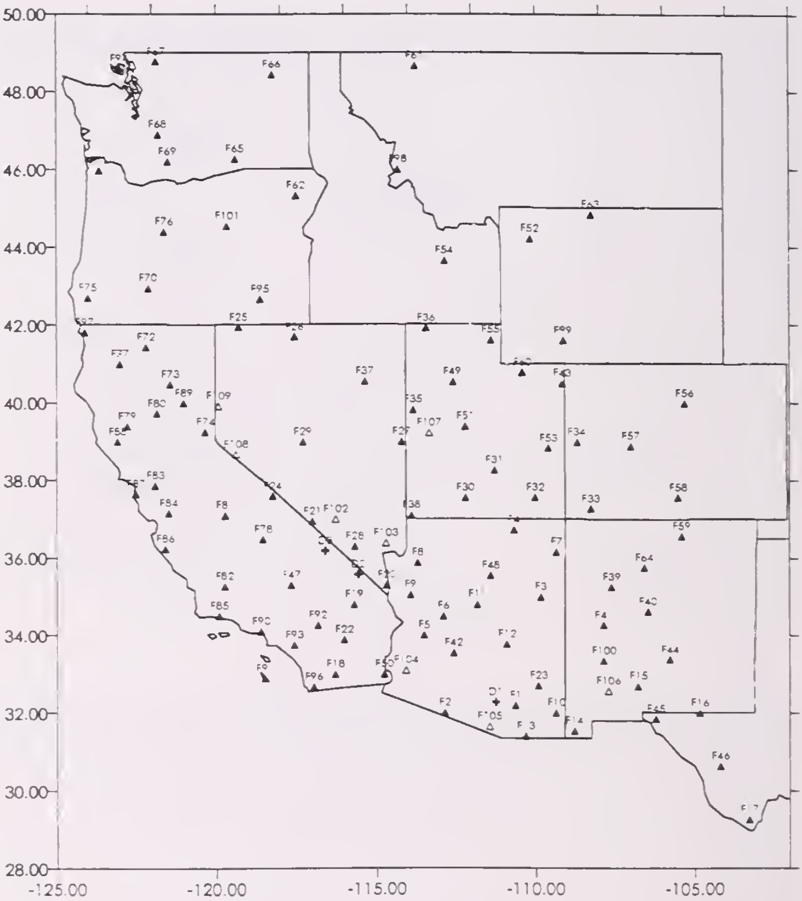

Fig. 1. Distribution of local floras from the western USA included in the data base for the current study. Floras (including substitutions, Table 2) used in previous studies are shown with a solid triangle, permanent additions are shown with open triangles, and temporary additions are shown with "+" signs.

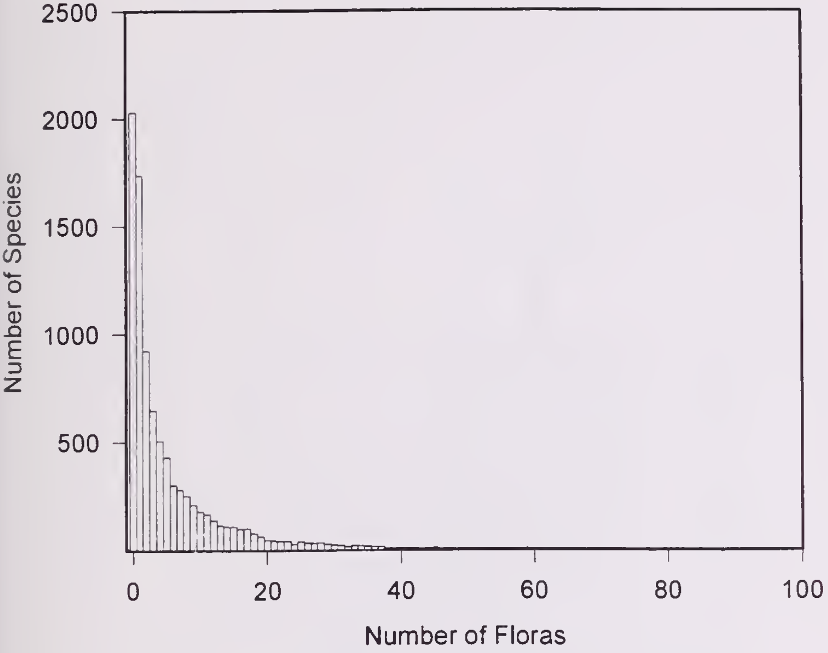

Fig. 2. Frequency distribution for 9158 species recorded in 109 local floras from the western USA.

This study is primarily concerned with subdivisions of the Sonoran Floristic Province, particularly those in the eastern Mojave Desert region. The PCA of the narrow species distinguishes four floristic entities within Sonoran Floristic Province (Figs. 7-10). The first is centered in the northern Mojave Desert with maximum loadings on the Nevada Test Site (F102), Grapevine Mountains (F21), and Black Mountains (D3) and is here designated as the "Northern Mojave Desert Element" (Fig. 7). The second is centered in the Colorado Desert area but extends well into the central part of the Mojave Desert area and up the Colorado River Valley into southern Nevada (Fig. 8); it is designated here as the "California Desert Floristic Element." The third is centered in southwestern Arizona (Fig. 9) with maximum loadings on Organ Pipe Cactus National Monument (F2), White Tank Mountains Regional Park (F42), and the Tucson Mountains (D1); it can readily be designated as the "Arizona Upland Floristic Element". The fourth component is centered in northwestern Arizona, southeastern Nevada, and southwestern Utah (Fig. 10) with maximum loadings on the floras of Lower Grand Canyon (F8), the Beaver Dam Mountains (F38), and the Muddy Mountains (F103). This last component is designated as the "Eastern Mojave Desert Floristic Element."

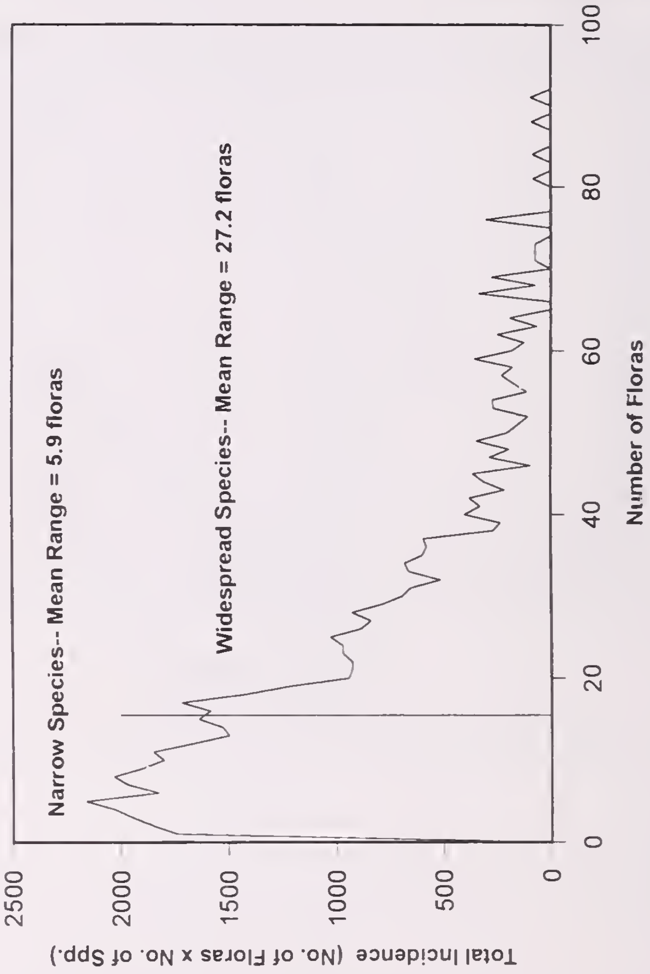

Fig. 3. Incidence of species from the western USA recorded in 109 local floras from the region. The total area under the curve is equal to the total number of recorded occurrences in the data base. The line dividing this area in half occurs at 15.5 local floras; species occurring in 15 or fewer local floras are treated as "narrow" species in the current analysis; those occurring in 16 or more local floras are treated as "widespread".

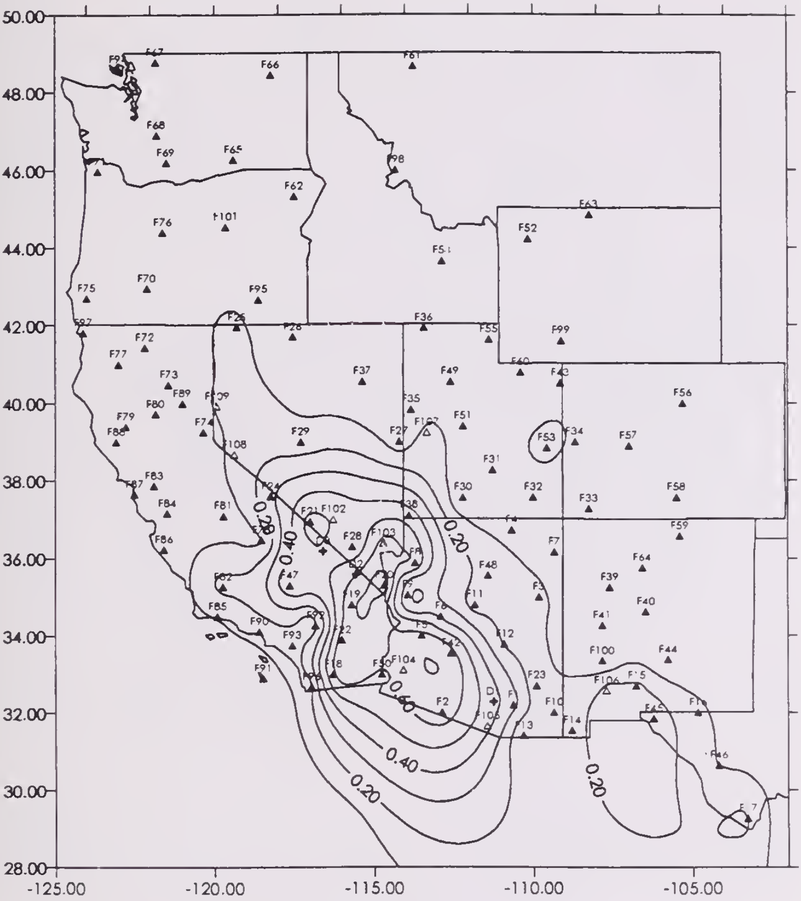

Fig. 4. Map showing the distribution of the Sonoran Floristic Element in the western USA, from the PCA of widespread species.

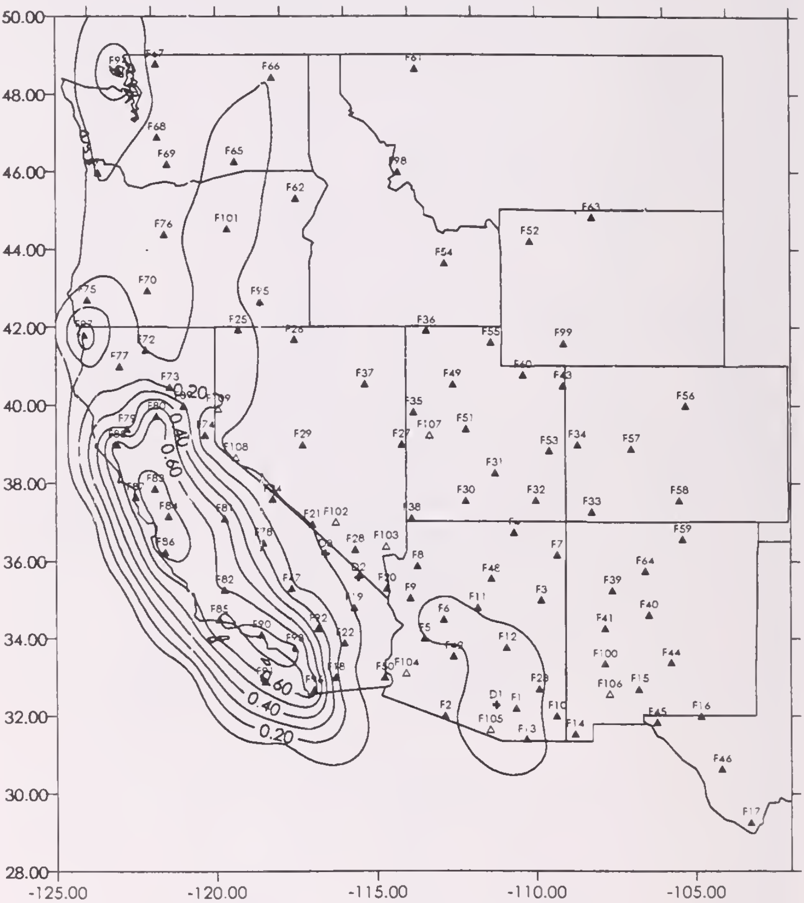

Fig. 5. Map showing the distribution of the California Floristic Element in the western USA, from the PCA of widespread species.

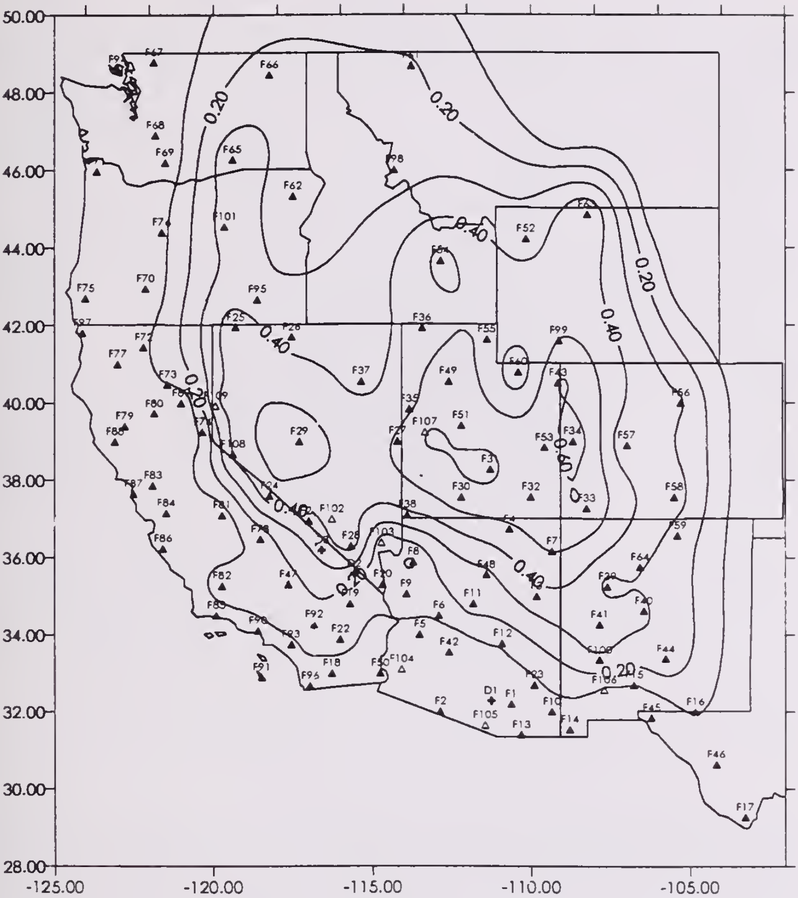

Fig. 6. Map showing the distribution of the Intermountain Floristic Element in the western USA, from the PCA of widespread species.

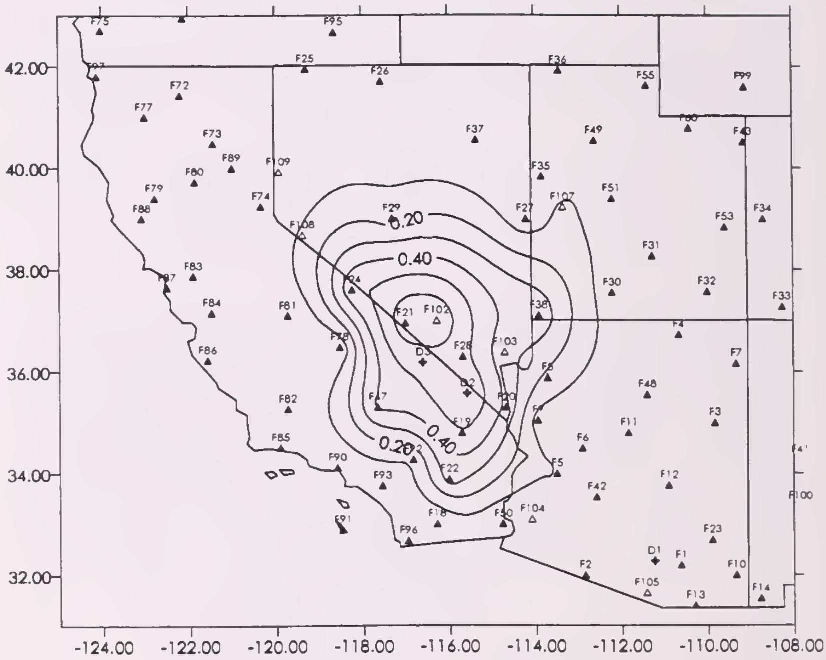

Fig. 7. Map showing the distribution of the Northern Mojave Desert Floristic Element in the western USA, from the PCA of narrow species.

Maps showing the approximate boundaries between floristic areas can be made by drawing lines around those floras having their highest loadings on a particular component (McLaughlin, 1994). Such a map for the Sonoran Floristic Province, based on the results from the present analysis, is given in Fig. 11. I previously recognized just three subdivisions of the Sonoran Floristic Province: a Colorado-Mojave Desert District, an Arizona Upland District, and a Northern Mojave Desert District (McLaughlin, 1992a). The Arizona Upland Districts of the two studies are identical. The Colorado-Mojave Desert District of McLaughlin (1992a) is the same as the California Desert District of this study, except that the floras for eastern Kern County (F47) and the Granite Mountains (F19) were included in the Colorado-Mojave Desert District of McLaughlin (1992a), and are placed in the Northern Mojave Desert District of this study. In hindsight, "Colorado-Mojave Desert District" was a poor choice for a name this floristic area, and "California Desert District" may not be much better. The name "Colorado Desert" seems inappropriate because the area in fact extends much further north than in all traditional treatments of the Colorado Desert.

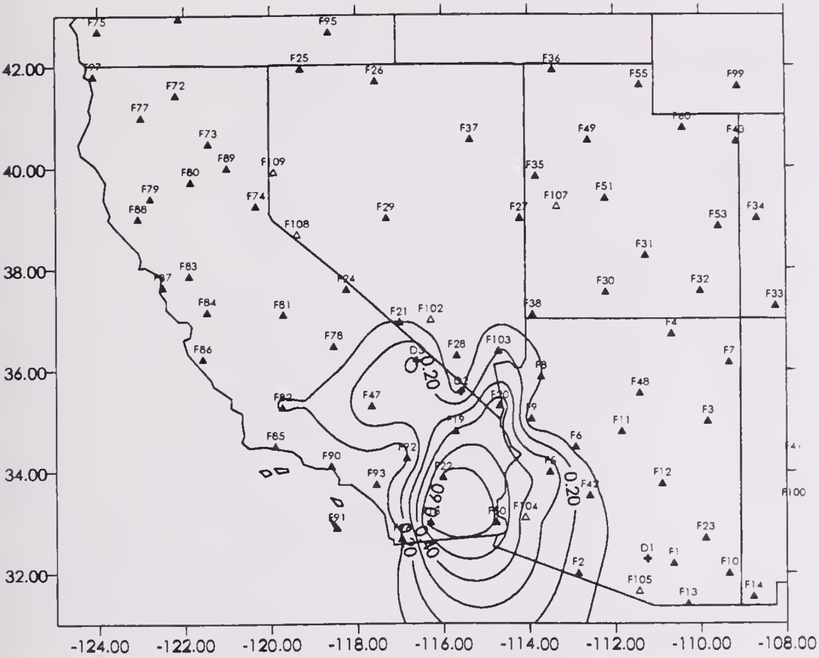

Fig. 8. Map showing the distribution of the California Desert Floristic Element in the western USA, from the PCA of narrow species.

The Northern Mojave Desert District of McLaughlin (1992a) was a somewhat dumbbell-shaped area made up of both the Northern Mojave Desert and the Eastern Mojave Desert districts of the present analysis. Expanding the data base with several additional floras from this area, including the Nevada Test Site (F102), the Muddy Mountains (F103), the Clark Mountains (D2), and the Black Mountains (D1) made a finer subdivision possible. Eastern Kern County (F47) and the Granite Mountains (F19), are placed in the Northern Mojave Desert District, rather than in the California Desert District (Colorado-Mojave Desert District of McLaughlin, 1992a), because many of the plant species found in these two floras also are recorded from several of the floras that have been added to the data base, effectively shifting their distributions--as recorded in the data base--northward. Both of these floras have comparatively high loadings (0.31 for F47, 0.41 for F19) on the California Desert component, however, so there is still some uncertainty in the placement of this boundary.

In the analysis of McLaughlin (1992a) there was a bipolar element (i.e., with both high positive and negative loadings) on which the floras for the Beaver Dam Mountains (F38) and the

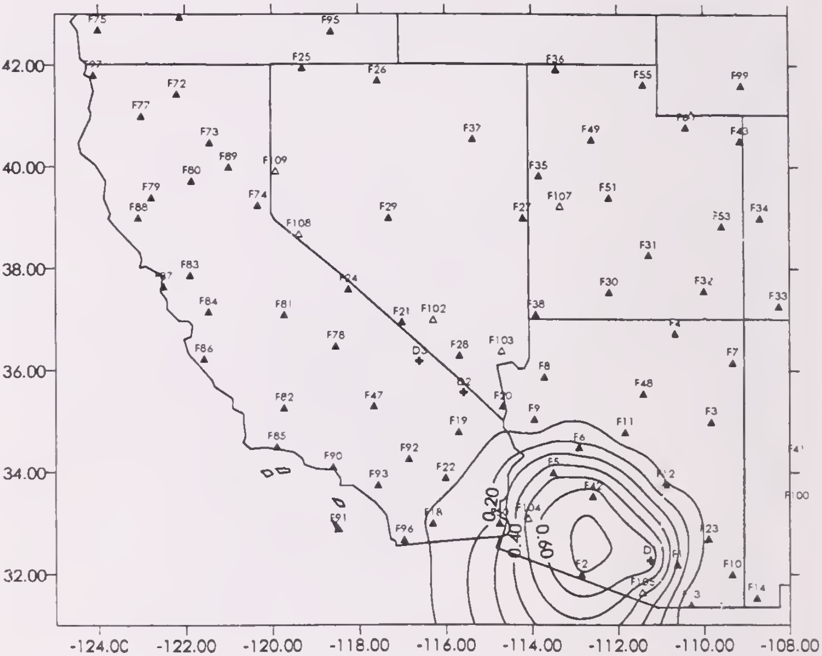

Fig. 9. Map showing the distribution of the Arizona Upland Floristic Element in the western USA, from the PCA of narrow species.

Lower Grand Canyon (F8) had high loadings. Bipolar components are best interpreted as artefacts of the PCA rather than as distinct clusters of sample points (McLaughlin, 1994). Floras F8 and F38 were thus combined into the Northern Mojave Element on which they also had high loadings. Addition of the floras for the Nevada Test Site (F102) and Muddy Mountains (F103) allow for a clearer distinction between the Northern Mojave Desert element and the eastern Mojave Desert Element in the present analysis.

As in McLaughlin (1992a), the Colorado River appears to be an important boundary between floristic elements in southeastern California and southwestern Arizona in this study (Fig. 11).

The "eastern Mojave Desert" region of San Bernadino County, which was catalogued by Thorne et al. (1981) and includes the Clark Range (D2) and the Granite Mountains (F19) floras, is placed here in the Northern Mojave Desert District. Although this area is "east" in California, it is actually situated in the center of the northern half of the Sonoran Floristic Province in the western USA (Fig. 11). The name "Eastern Mojave Desert" seems better applied to that portion of the Sonoran Floristic Province that occurs at the northeastern end of the province in north-

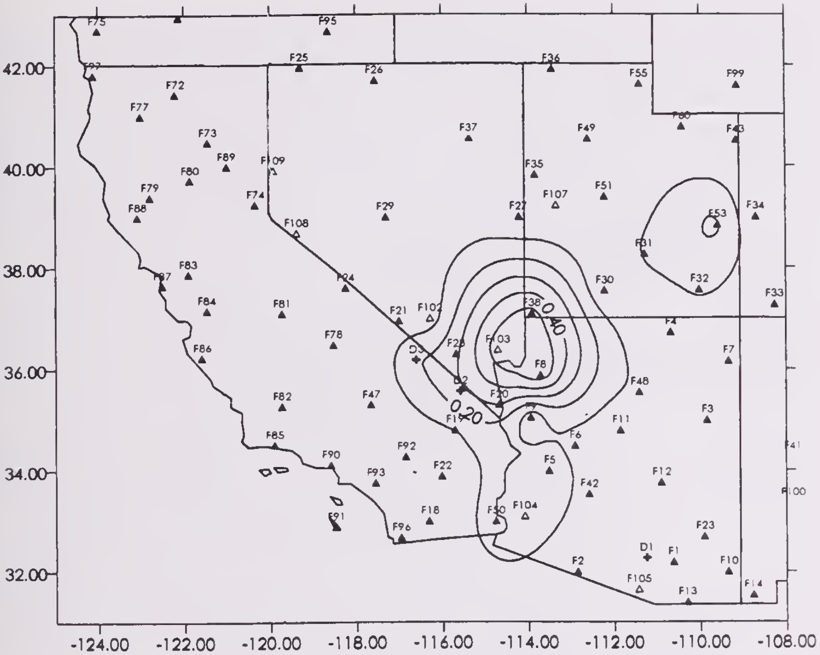

Fig. 10. Map showing the distribution of the Eastern Mojave Desert Floristic Element in the western USA, from the PCA of narrow species.

western Arizona, southeastern Nevada, and extreme southwestern Utah. The "eastern Mojave Desert" area of California is an area where several floristic elements converge, including the Northern Mojave Desert, Eastern Mojave Desert, and California Desert elements (Figs. 7, 8, 10). In addition, the Intermountain Floristic Element also extends well into the area (Fig. 6), providing the area with many widespread species of more northerly distributions, and the Madrean element (map not shown) reaches its northwestern limit in the area.

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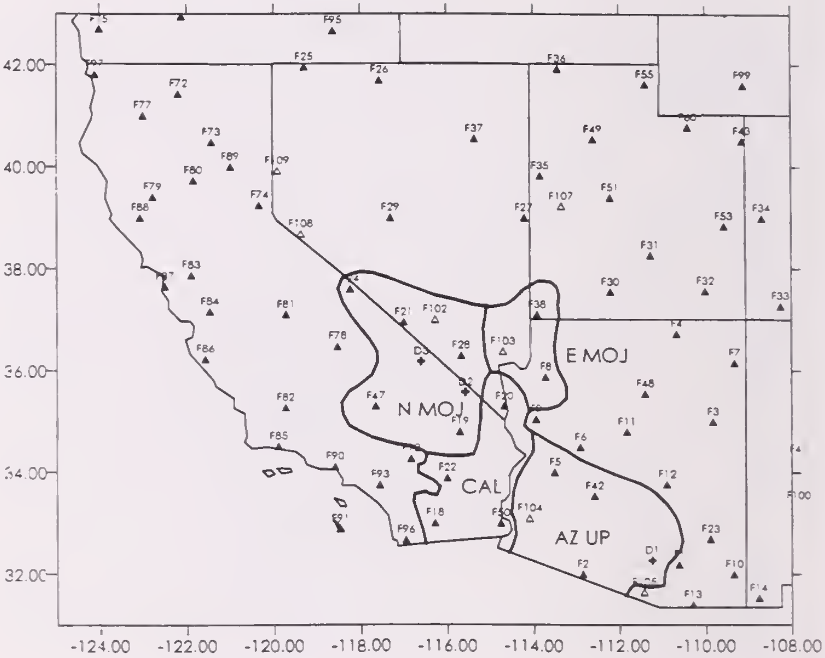

Fig. 11. Map showing the subdivisions of the Sonoran Floristic Province in the western USA as delimited in this study. Abbreviations are: N MOJ--Northern Mojave Desert Floristic District; CAL--California Desert Floristic District; AZ UP--Arizona Upland Floristic District; and E MOJ--Eastern Mojave Desert Floristic District.

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Book Review

CNPS Inventory of Rare and Endangered Vascular Plants of California 5th Edition by Mark W. Skinner and Bruce M. Pavlik, Editors. 1994. 336 pages. California Native Plant Society, Sacramento, California. Softcover (ISBN 0-943460-18-2) $22.95.

This 5th Edition is entirely updated and lists 1742 types of California's native plants that are now rare, endangered, or uncommon in California. This number represents nearly 28% of California's 6300 native plants and shows continued decline of the State's magnificent native flora. The California flora is the largest and perhaps most spectacular assemblage of plants in North America. More than one-third of the state's native plants are found nowhere else on earth, and nearly one-fourth of all the North American vascular plants occur here.

Among the 1742 special status plants in California, the INVENTORY lists 857 species, subspecies and varieties that are "rare, threatened, or endangered in California and elsewhere," nearly 14% of the flora. This is an increase of 27% -- a net increase of 182 plants -- since the fourth edition of the INVENTORY was published in 1988. Thirty-four plants that occurred in California are now extinct in the state. Since the last edition was published 13 plants thought to be extinct in California were rediscovered, but eleven new plants are now presumed to be extinct.

Useful features in the new entirely revised and updated 5th edition include:

- expanded introduction, including new discussions of rarity, rare plant ecology, CNPS, state, federal and global programs
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- status and distribution summaries for 1742 of California's rarest plants
- all state and federal-listed plants and candidates
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- topographic and quad data for more than 1200 plants
- county data for all 1742 plants
- new appendices of quads (now listed by name and number) and plants new to this edition

This summary of the latest information on the state's rare and endangered vascular plants includes ferns, fern allies, cone-bearing seed plants and flowering plants. Land resource managers, conservationists, field biologists, consultants, and botanical researchers will find this INVENTORY an indispensable reference for identifying, protecting, and managing California's rarest botanical resources.

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